The
GEOGRAPHICAL JOURNAL

Vol LXXXII No 4 R.G.S. *October 1933*

THE QATTARA DEPRESSION OF THE LIBYAN DESERT AND THE POSSIBILITY OF ITS UTILIZATION FOR POWER-PRODUCTION

DR. JOHN BALL, O.B.E., M.INST.C.E.

IN a paper on "Problems of the Libyan Desert," published in the *Geographical Journal* for 1927,[1] I included a short account of a great natural hollow—the Qattara[2] Depression—which had been recently discovered to exist in the northern part of the Libyan Desert; and I also referred briefly to the possibility of that depression being utilized for the generation of power by admitting sea-water into it with a considerable fall from the Mediterranean, the influx being continuously disposed of by evaporation from the surface of the salt lake which would thus be formed within the depression.

At the time when I wrote the above-mentioned paper, the depression had not been completely surveyed; even its outline had only been approximately traced, and though its lowest point, 134 metres below sea-level, had been located, and spot-levels had indicated that a vast area lay more than 50 metres below the level of the Mediterranean, the measurements which had up to that time been made, and the various other data which had been collected relative to the depression and the desert tract between it and the sea, were insufficient for more than a very rough idea to be formed in regard to its possibilities for power-production.

Since 1927 however contour-mapping has been carried out by the Survey of Egypt over the entire area of the depression, so that its exact extent and its contours at various levels below sea are now known, as well as the limits of the *sabakha* (salt-marsh) within it and the general nature and distribution of the various rocks composing its floor; the eastern part of the elevated desert tract which separates the depression from the Mediterranean has likewise been mapped in detail, and borings have been put down for the purpose of ascertaining the underground structure; systematic evaporation-observations have been conducted on the Birket el Qarun (a brackish lake 45 metres below sea-level in the neighbouring depression of the Faiyum) in order to obtain data from which to estimate the average rate at which evaporation could be expected to take

[1] *Geogr. J.*, vol. 70, 1927, pp. 21–38, 105–138, and 209–224.

[2] Pronounced *Gat-tár-a;* or by some, *Kat-tár-a.*

place from a salt-lake within the depression; and further observations of static water-levels in various parts of the Libyan Desert, including those in a number of new wells, have been made with a view to extending previous knowledge concerning the distribution of underground water beneath it: a matter which is of considerable importance in connection with the question of seepage into or out of a lake within the depression.

As a result of all this more recent work, it is now possible not only to give further and more precise particulars of this remarkable depression, but also to study with some closeness a number of fundamental data bearing on the question of its future utilization.

The Depression

The situation, size, and general shape of the depression will be most readily grasped from an inspection of the map on the accompanying folding plate, which shows the principal contours of the depression and its surroundings as reduced (with some slight generalization of the contours for clearness) from the large-scale survey-sheets. It will be seen from this map that although bounded on the north and west by escarpments, the depression is more open on the south and east, its floor in these parts mostly rising very gradually to merge in the general desert-level. It is thus difficult to specify the extent of the depression in the last-named directions, except by regarding it as being limited by some definite contour. For our present purpose we may conveniently regard the sea-level contour as marking the limit of the depression, or, in other words, we may consider the depression to comprise only the tract which lies below the level of the sea. As thus defined, the depression has a length from north-east to south-west of 298 kilometres, a maximum breadth of 145 kilometres, and an area of 19,500 square kilometres. It includes within its borders the two small oases of Moghara and Qara, of which only the latter is permanently inhabited. At its narrow eastern end, near which Moghara is situated, the depression approaches within 205 kilometres of Cairo and 56 kilometres of the Mediterranean coast; while at its western extremity, near which Qara lies, it reaches to within 80 kilometres of the principal village of the Oasis of Siwa and 130 kilometres of Egypt's western frontier. The floor of the depression averages 60 metres in depth below sea-level. The lowest point in it, 134 metres below sea, is near its western end, about 30 kilometres south-east of Qara Oasis. Around Moghara and Qara the general level of the depression-floor is comparatively little below that of the sea, both these oases lying, in fact, in slight local deepenings of the shallower marginal parts of the depression.[1] But of the 19,500 square kilometres which comprise the total area of the depression-floor, no less than 13,500 square kilometres lie at depths exceeding 50 metres below sea.

A large proportion (about 5800 square kilometres) of the floor of the depression is covered by *sabakha*, which is a mixture of sand and salt, generally with more or less water. In some tracts the *sabakha* directly overlies solid ground, presenting a rough ridgy surface which can be travelled over, though with difficulty, in dry seasons; but over large areas it forms merely a solid or semi-

[1] On the folding map the small local deepening within which Qara lies has been tinted yellow in error; it should properly bear the grey tint corresponding to depths of 25 to 50 metres below sea-level.

solid crust overlying salty sludge, and is therefore quite impassable. The remainder of the depression-floor is mostly formed of sands, gravels, clays, and limestones, the general distribution of which can be seen in the sketch-map, Fig. 1.

The depression is believed to have been mainly formed in Pleistocene and recent geological times by the excavating action of the wind on the nearly horizontally bedded soft rocks which constitute the Miocene formation in this part of Egypt, and which are well exposed in the face of the great escarpment bounding the depression on the north. Large quantities of the sandy constituents of the rocks removed by wind-action in the process of formation of the depression have been blown south-south-eastwards and deposited in the form of great lines of sand-dunes, some of which are to be seen in the most

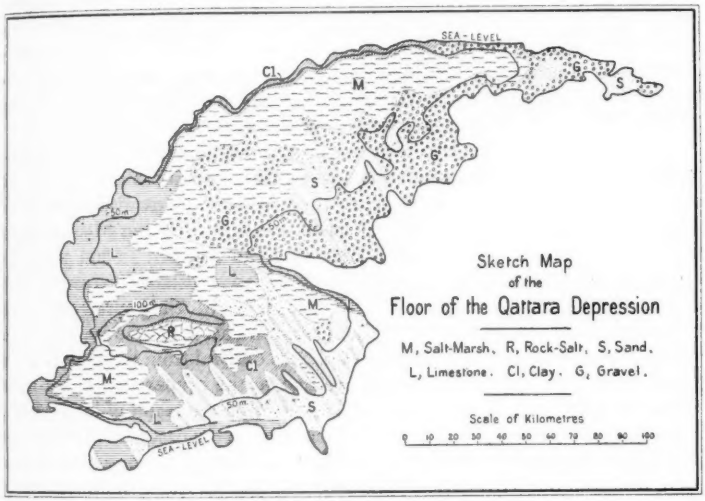


Fig. 1

southerly part of the depression itself, while others stretch for long distances over the desert beyond it.

As will be seen from the sketch-map in Fig. 1, the salt-marsh does not form a single continuous expanse, nor does it invariably cover the deepest parts of the depression, the very lowest point of the depression being in fact on dry clayey ground, free from *sabakha*. The largest continuous sheet of *sabakha* is that which sweeps round from near the north-eastern end of the depression past the foot of the northern escarpment and then divides into three branches near the middle of the depression. Farther south the *sabakha* occupies several detached areas of the depression-floor. It is a remarkable fact that the marsh does not by any means lie at a constant level, even within the limits of each continuous tract of it. In the case of the largest sheet just referred to, for instance, it is only about 50 metres below sea at its eastern end; but it slopes gradually downwards to the west, and its main expanse lies at a nearly uniform

depth of about 80 metres below sea-level. The smaller, but still very extensive, tract of marsh near the south-western corner of the depression exhibits even greater variations of level, being only 45 metres below sea at its south-western extremity, but descending to 122 metres below sea in its northern parts.

In the deeper portion of the depression the contour of 100 metres below sea-level is rather curiously forked towards the east, owing to the intervention of a low plateau, of which the surface is about 30 metres above the area around it, and which extends for about 35 kilometres east and west with an average breadth of about 6 kilometres. This plateau is capped by a thick bed of massive translucent rock-salt, very different from the *sabakha*. Whether we have here the remains of a lenticular salt-deposit which was originally intercalated in the Miocene strata, or of a similar deposit laid down on the bed of a lake which may have existed within the depression at some intermediate stage of its excavation, is not quite certain; but in either case the persistence of this plateau is obviously due to the massive rock-salt which forms its surface offering greater resistance to atmospheric influences than the soft clays which surround and underlie it; and it thus affords evidence of the prevalence of a dry climate in this region through a very considerable period of the past.

An examination of the surveyed contours of the depression and of the surrounding desert seems to show conclusively that the sea has never had direct access to the depression, either during the process of its excavation or subsequently. Further, there appears to be no seepage from the Mediterranean into the depression; for borings carried down to between 20 and 30 metres below sea-level between the sea and the depression at distances exceeding some 20 kilometres from the coast are quite dry. A few trickling springs enter the depression near the foot of the northern escarpment; but these are of brackish water, and their scanty supplies are doubtless derived from local rainfall. We cannot therefore regard the *sabakha* as due to the evaporation of sea-water formerly occupying the depression. Nor can it be the result of local rainfall, even though that may possibly have been greater in the past than at the present day; for although local rainfall on the higher parts of the floor would dissolve salts from the rocks over which it flowed and deposit them on evaporation at lower levels, we could not possibly account in this way for the present-day existence of the large volume of water which lies beneath the *sabakha*, because evaporation at present so vastly exceeds rainfall in this region, that any salt marsh resulting from such a cause would long since have been completely dried up. We are thus driven to conclude that the *sabakha* and the salt water and sludge which now underlie it over large areas are due to a continual seepage of underground water into the depression, the depression forming, in fact, a sump for the great subterranean water-sheet which, originating in the Ennedi highlands far to the south-west, flows underground beneath the Libyan Desert and supplies the artesian wells of Kharga, Dakhla, Farafra, Bahariya, and Siwa Oases. This view of the origin of the salt marsh is supported by what has been observed in wells which have lately been sunk within the depression and outside it; in every case these have reached water at levels in agreement with such an explanation, and the character of the water found in the various wells indicates that while the water of the underground sheet in general retains a high degree of purity so long as it flows through the Nubian

sandstone, it absorbs in some places considerable quantities of salt in its passage through younger rocks before reaching the Qattara Depression.

The levels of the *sabakha* in various parts of the depression may in general be taken as practically marking the static levels of the underground water-sheet in those parts. With evaporation continually operating to dispose of the underground water which emerges on the floor of the depression, the static water-level at any point will of course depend on the local rate of efflux, which in its turn will depend largely on the nature of the rocks through which the water has to percolate before reaching that particular point; and as the Miocene rocks through which the water of the underground sheet has to pass to reach the depression exhibit considerable lateral and vertical variations in porosity, as well as in the amount of soluble salts they contain, the varying levels of the *sabakha* in different parts of the floor of the depression are easily explained. The same consideration enables us to account for the otherwise puzzling configuration of the floor of the depression, with its deepest point close to the western border instead of near the centre; for excavation by wind-action would naturally be largely arrested when it had reached the depth at which the ground became soaked with seepage-water; and this depth would be greatest where the static underground water-level was lowest.

Areas, Capacities, and Mean Depths of the Depression for various Contour-boundaries

The following table gives in round numbers the areas and capacities of the depression at different contour-levels, and the mean depths below those levels, together with the shortest distances from the Mediterranean coast to the various contours, and the distances from Tanta (a large town near the centre of the Delta) to that point of each contour which is nearest to the coast. The areas and distances have been carefully measured from the large-scale 1:100,000 field-sheets of the Survey, which show the sea-level contour and also the contours at 5-metre intervals from 40 metres below sea-level downwards. The capacities and mean depths have been calculated on the assumption (which is known to be very nearly correct) that the rate of diminution of area with increase of depth is constant between any given contour and the one next below it:

Contour	*Included area*	*Capacity below contour*	*Mean depth below contour*	*Shortest distance from contour to coast*[1]	*Distance from Tanta to contour-point nearest coast*
0	19,500 km.²	1167 km.³	60 m.	56 km.	206 km.
−40 m.	14,800	481	32	63	230
50	13,500	340	25	70	247
60	12,100	212	17	76	280
70	8,600	108	13	80	312
80	4,430	42	10	96	316
90	1,070	14	13	195	398
100	460	7	15	200	410
−120 m.	134	1	7	208	427

[1] The positions of the lines corresponding to these shortest distances are indicated on the map which forms the folding plate, Line D being that to the −50-metre contour, and Lines E and F being those to the −60 and −70-metre contours respectively.

Rainfall

The rainfall maps recently published by the Physical Department of the Egyptian Government indicate that the present mean rainfall over the Qattara Depression is about 20 mm. per year, or about 0·06 mm. per day. The local rainfall would doubtless be somewhat increased if a salt-lake were to be formed within the depression; and it is, of course, this increased rainfall which would have to be offset against evaporation in estimating the maximum rate at which sea-water could be admitted into the depression without causing rise of level in a lake after its formation.

A very rapid diminution in the mean annual rainfall is noticeable as one proceeds inland from the Mediterranean coast towards the depression. Along the coast there is an average of 200 mm. of rain a year, while over the depression, less than 100 kilometres inland, the rainfall averages only a tenth of that amount. The direction of the prevalent winds being from over the sea towards the interior, it would seem natural at first sight to ascribe the rapid inland diminution of rainfall to a desiccation of the air in its passage over the desert, and to infer that the flooding of a large area of the desert at no great distance inland would exert a strong humidifying influence, and thus bring about a considerable augmentation of the local rainfall, with great benefit to the littoral agriculture. But I am assured by meteorologists that such a view would be mistaken, the local rainfall depending essentially on the general atmospheric circulation over very wide areas of the Earth's surface, rather than on the local configuration of land and water, so that the desert is the consequence, not the cause, of the inland diminution of rainfall. The meteorologists whom I have consulted on the subject have unanimously expressed the view that the formation of a salt-lake within the depression would cause at most only a very small augmentation of the mean annual rainfall over and around it.

From the point of view of the utilization of the depression for power-production however rainfall is an adverse factor, and it is therefore important that it should not be under-estimated. To be on the safe side, let us assume that the present average rainfall of 0·06 mm. per day over the depression would be doubled when a lake was formed within it; and let us also assume that in addition to the rain which would fall on the lake itself, one-half of that which would fall on the remainder of the depression would find its way into the lake. Then, the areas of the depression at the sea-level contour and at the contour of −50 m. being respectively 19,500 and 13,500 sq. km., the thickness of the average daily layer of water which a lake of 50 metres below sea-level would receive from rainfall would be 0·15 mm. Similarly the thicknesses of the average daily rainfall-layers for lakes at 60 and 70 metres below sea would be 0·16 and 0·18 mm. respectively.

Evaporation

There being no open expanse of water at present within the Qattara Depression, we are compelled, in endeavouring to forecast the probable rate of evaporation from a lake formed within it, to base ourselves on observations made elsewhere under as nearly as possible similar conditions of climate and exposure.

Careful investigations carried out by the Physical Department during several years on the Birket el Qarun, a brackish lake 45 metres below sea-level in the

neighbouring depression of the Faiyum,[1] indicate that the mean daily evaporation from that lake is 5·5 mm.; and it has been found by experiment that, as might be expected, evaporation takes place at a slightly greater rate from fresh water than from the brackish water of the Birket el Qarun. Now the Qattara Depression lies somewhat nearer to the heart of the Libyan Desert than does the Faiyum, so that although the exposure is similar in the two depressions (a high cliff bounding them both to the north-west), evaporation would probably be somewhat more rapid in the Qattara Depression than in the Faiyum. We may therefore feel certain of being on the safe side if we adopt 5·5 mm. per day as the probable average rate at which evaporation would take place from the surface of a *freshwater* lake in the Qattara Depression.

The only observations of the rate of evaporation from an open surface of saturated or almost saturated brine which I have been able to trace are those briefly referred to by Professor Hann[2] as having been made on the Karabugas, a nearly land-locked gulf of almost saturated brine on the eastern side of the Caspian Sea, where the annual rate of evaporation was found to be a little over 1 metre. The latitude of the Karabugas is some 10° north of that of the Qattara Depression, and the mean annual temperature about 6° C. lower; and although the Transcaspian climate is a very dry one, the average yearly rainfall at Kraslovodsk, only a little to the south of the Karabugas, is about 15 centimetres,[3] as compared with the 2 centimetres which falls over the Qattara Depression. It therefore seems likely that evaporation will be at least as rapid in the Qattara Depression as in the Karabugas; and in the absence of any other guide, we shall assume that the probable average rate of evaporation from a lake of *saturated brine* within the Qattara Depression would be the same as that from the almost saturated brine of the Karabugas, namely, a little over 1 metre per year, or say, 2·8 mm. per day.

There would thus be a total decrease of 2·7 mm. per day in the average daily evaporation from a lake within the depression as its contents passed from the condition of fresh water to that of a saturated brine. We shall probably not be greatly in error if we assume that the falling-off in the rate of evaporation would be proportional to the increase in the amount of contained salts; and since the salt-content of saturated brine is just about tenfold that of sea-water, we may infer that the average daily evaporation in mm. from a lake of salinity n times that of sea-water, situated within the Qattara Depression, would be equal to $5{\cdot}5 - 0{\cdot}27n$. Hence we have the following values:

Salinity in terms of sea-water	0	1	2	3	4	5	6	7	8	9	10
Average daily evaporation, mm.	5·5	5·2	5·0	4·7	4·4	4·1	3·9	3·6	3·3	3·1	2·8

If a salt-lake were to be formed within the depression by the admission of sea-water, and maintained at a constant level by the continual passage of sea-water into it, the salinity of the lake would at first be the same as that of

[1] Shown on the map which forms the folding plate.
[2] Hann, *Lehrbuch der Meteorologie*, 2. Aufl. Leipzig, 1906, p. 158.
[3] Hann, *Handbuch der Klimatologie*, Band 3, Stuttgart, 1911, p. 265.

the sea, but would gradually increase as time went on, owing to continual evaporation, until the condition of a saturated brine was reached; after which the salinity of the lake would remain constant for a very long period, while salt was being deposited on its floor.

For calculations relative to prospective power-production it is obviously only necessary for us to consider what would be the *average* degree of salinity of the lake during some definite long period following the first admission of sea-water into the depression; and we may adopt one hundred years as representing a suitable definite period for our purpose. Preliminary calculations which I have made (the nature of which will be evident further on when we come to consider the question of increase of salinity of the lake) show that if sea-water were to be admitted from the beginning at rates which would eventually maintain lakes at final levels of 50, 60, and 70 metres below sea respectively, then the average salinities of those lakes during the first hundred years of their existence would be roughly about $3\frac{1}{2}$, $4\frac{1}{2}$, and $5\frac{1}{2}$ times that of sea-water respectively. Hence the average rates of evaporation from the surfaces of those lakes during that period would be about 4·6, 4·3, and 4·0 mm. per day respectively.

Inward seepage

As already mentioned, there is at present a continual seepage of underground water into the depression from the east and south, at levels approximating to those of the salt-marsh, that is, at levels ranging from about 45 to 80 metres below the sea, but principally at about the latter level. This underground water originates as rainfall in the highlands of the Ennedi region of French Equatorial Africa, and the depression forms the terminal sump for a considerable proportion of the northward underground flow, the water being ultimately disposed of by evaporation from the salt-marsh which covers large areas of the depression-floor.

If a lake were to be formed within the depression, the static levels of the underground water beneath the area covered by the lake would be raised from their present average value of about 80 metres below sea-level to that of the lake surface; and the rise of the static levels would extend, in gradually lessening amount, for considerable distances to the southward. But even if the lake surface were as high as 50 metres below sea-level, the depression would still form a sump for the underground flow, for there is no other depression of the Libyan Desert which descends to this level. There would of course be some flattening of the static gradient to the south of the depression, and this would tend to diminish the velocity of the underground flow, while the rise in static levels to the south would tend to increase the amount of water abstracted from the underground sheet in the oases and other depressions wherein it is now tapped. But the total withdrawals of water in all these places taken together are probably so small compared with the surplus which is left to seep into the depression, that even a considerable increase in the amount withdrawn would not greatly reduce the surplus; while in the absence of any other large depression of equal or greater depth into which the surplus could drain, it seems unlikely that the slight flattening of the static gradient would be accompanied by any very marked diminution of the present amount of seepage into the

depression. And inward seepage being, like local rainfall, an adverse factor as regards the utilization of the depression for power-purposes, it will be best for us to keep on the safe side by assuming that the total inward seepage into a lake within the depression would be the same as that which at present takes place into the salt-marsh.

We can obtain a fair idea of the total annual amount of this inward seepage if we can estimate the annual evaporation from the salt-marsh; for it is obvious that evaporation from the salt-marsh on the whole just about balances inward seepage plus local rainfall. It is however difficult to make more than a rough guess at the annual evaporation from the salt-marsh, covered as it is almost entirely by a semi-solid crust of mixed sand and salt; for in summer, when evaporation would otherwise be most rapid, the salty crust dries up over large areas and screens the watery ground below from exposure, while in the winter the conditions may at certain times be such that the hygroscopic property of the salt will cause it to attract moisture from the air, rather than to give it up. From what I have seen of the *sabakha* at various seasons, it seems to me likely that the average rate of evaporation from the salt-marsh may be somewhere about one-fifth of that which would take place from a brine-lake of equal area, or about 20 centimetres a year, of which about 2 centimetres will represent local rainfall. The total area of the marsh being about 5800 square kilometres, this gives about 1 cubic kilometre for the total volume of inward seepage-water annually entering the depression. Spread over surfaces of 13,500, 12,100, and 8600 square kilometres (these being the areas of lakes at 50, 60, and 70 metres below sea) this cubic kilometre corresponds to thicknesses of 78, 87, and 122 millimetres for the layers of water which would be added per year, or of 0·21, 0·24, and 0·33 millimetres for the layers which would be added per day, to lakes at 50, 60, and 70 metres below sea respectively.

Outward seepage

There could be no *continuous* outward seepage from a lake 50 metres or more below sea-level within the depression, for the simple reason that there is no open area at a lower level to which outward-seeping water could continuously migrate. Nor would there be any outward seepage involved in the raising of the static underground water-levels in the south; for the porous beds through which the underground flow now reaches the depression from the south are already saturated with water, mostly under artesian pressure. The only outward seepage which could possibly occur would be that which would go to saturate such porous strata around the lake as lie above those which convey the artesian water and below the level of the lake itself; and when once this saturation had taken place, outward seepage would cease, because when once the beds were saturated the water would have no means of escape, and would moreover be protected from evaporation by the overlying strata.

To estimate the average daily lowering of the lake-surface by outward seepage over a period of say a hundred years from the first admittance of sea-water into the depression, therefore, we have first to estimate the total absolute volume of the outward seepage, and then to find the thickness of the lake-layer to which this would correspond if the rate of seepage were constant and it took a hundred years for that total absolute volume to pass out.

Along the greater part of the northern side of the depression the rocks forming the lower part of the bounding cliffs are impermeable clays, into which there would of course be practically no outward seepage. As the eastern end of the depression is approached, these clays give place to gravels and sands, which are very porous; but from the geological section on p. 310 it will be seen that intercalations of clay exist which dip to the northward in such a way as to cut off the possibility of the outward seepage extending very far to the north. Along the eastern and south-eastern borders of the depression, the rocks are frequently porous; but the evidence furnished by both old and new wells in this area shows that there has here been such an extensive upward leakage from the artesian beds into the overlying sands and gravels as to saturate them up to the static water-levels; and the static contour of 50 metres below sea-level follows a course so little to the east and south-east of the corresponding ground-contour that outward seepage from a lake at 50 metres or more below sea-level could nowhere extend more than a short distance in these directions. Along the western and southern borders of the depression the rocks are predominantly limestones with intercalated clays, which would absorb but little water except along cracks and fissures, and these do not appear to be numerous; while the existence of permanent lakes at levels comparatively little below that of the sea in the depressions of the Siwa group farther west tends to indicate that the present saturation-levels rise to the westward. Taking all these facts into consideration, we may infer that the total volume of rock which would be saturated by outward seepage from a lake at any level would probably not greatly exceed the product of the area included between the contour of the final lake-surface and the contour corresponding to the present average saturation-level into half the vertical distance between these two contours; and we may assume the present average saturation-level around the borders of the depression to be somewhere about 75 metres below sea. In the case of a lake 50 metres below sea-level, this gives 85 cubic kilometres for the approximate total volume of rock to be saturated; and taking 15 per cent. as representing the probable average degree of porosity of the rocks, we have 12·5 cubic kilometres for the approximate total absolute volume of water which would escape by outward seepage from the lake. Since the average area of the water-surface of the lake during the century following the commencement of its formation would be about 12,500 square kilometres, this corresponds to a thickness of 1 metre for the water-stratum to be removed by outward seepage in one hundred years, or to an average daily lowering of the surface by less than 0·03 millimetre. For lakes at 60 and 70 metres below sea-level, corresponding calculations give 0·015 and 0·001 millimetres respectively. Outward seepage is of course a favourable factor from the point of view of the utilization of the depression for power-purposes; but the above consideration shows that the lowering of lake-surface resulting from it would be so insignificant as to be altogether negligible compared with that which would be caused by evaporation, and we shall therefore disregard outward seepage in calculating the permissible rate of influx of sea-water into the depression.

It is to be remarked that there would be no possibility of the drainage of the Faiyum province being interfered with, nor of the oases of Moghara, Qara, and Siwa being damaged, by outward seepage from a salt-lake within the

depression, even if the lake-surface were as high as 50 metres below sea-level; for in none of these places do the ground-levels descend so low as this.

Permissible rate of influx of sea-water

The daily volume of sea-water which could be permitted to pass continuously into the depression would of course be the product of the final lake-area into the difference between the average thickness of the layer of water which would be removed per day by evaporation plus outward seepage and the average thickness of the layer which would be added per day by rainfall plus inward seepage. Hence we have, using the figures already found for these quantities, and neglecting the effects of outward seepage as being too insignificant to be worth taking into account for our purpose:

Final level of lake-surface below sea, metres ..	50	60	70
Rainfall, mm. per day	0·15	0·16	0·18
Inward seepage, mm. per day	0·21	0·24	0·33
Rainfall+inward seepage per day	0·4	0·4	0·5
Evaporation, mm. per day	4·6	4·3	4·0
e=Thickness of layer of permissible daily influx, mm.	4·2	3·9	3·5
A=Final area of lake-surface, sq. km.	13,500	12,100	8600
i=Permissible influx in millions of cubic metres per day	56·7	47·2	30·1
Q=Permissible influx in cubic metres per second	656	546	348
I=Permissible influx in cubic kilometres per year	20·7	17·2	11·0
E=Net thickness of layer annually disposed of by evaporation, etc., in metres	1·53	1·42	1·28

Time required to form lakes

If a is the area, in thousands of square kilometres, of the lake-surface when it has attained to the level of l metres below sea, I the volume, in cubic kilometres, of the annual influx into the lake, and E the thickness in metres of the water-stratum removed annually by evaporation and other causes, then the time-interval dt which will be occupied in the production of a small rise dl in the level of the lake will be $\frac{adl}{I/a-E}$, and the time t in years required for the lake-surface to rise from a level l_1 metres below sea to a higher level l_2 metres below sea will be $\int_{l_2}^{l_1} \frac{adl}{I/a-E}$, in which expression we may with sufficient approximation for our present purpose assume E to be a constant having for each lake the appropriate mean value found above, while a is a variable depending on l. To render the expression integrable, we have therefore to replace a by its value in terms of l.

Now when the known areas of the depression at levels corresponding to different depths below sea-level are plotted on squared paper against the levels themselves, and a smooth curve drawn through the points so found, as is done in Fig. 2, the resulting curve is seen to approximate fairly closely to a chain of four straight lines of different inclinations, one extending from the level of 134 metres to that of 90 metres below sea, a second from 90 to 70 metres, a third from 70 to 60 metres, and a fourth from 60 to 40 metres. In other words,

lake-area is, to a fair degree of approximation, a linear function of lake-level, and can be expressed, in thousands of square kilometres, by $a=\alpha-\beta l$, where α and β have one pair of values when l is between 134 and 90 metres, another pair when l is between 90 and 70 metres, a third when l is between 70 and 60

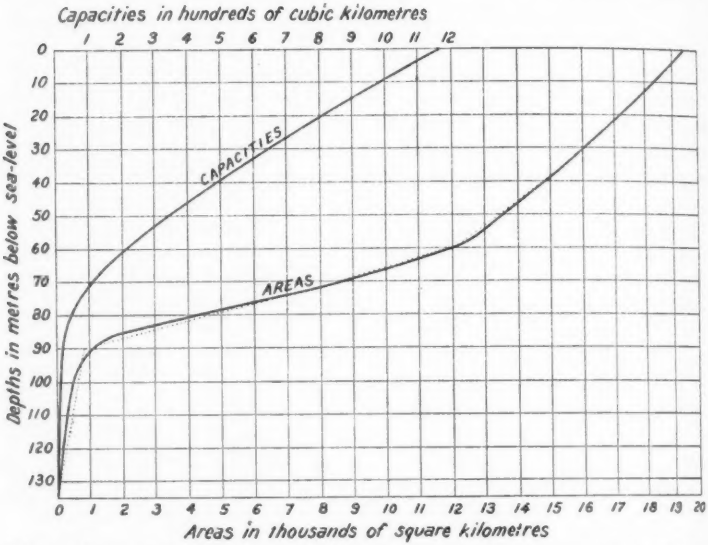

Capacities in hundreds of cubic kilometres
1 2 3 4 5 6 7 8 9 10 11 12
0 10 20 30 40 50 60 70 80 90 100 110 120 130
Depths in metres below sea-level
CAPACITIES
AREAS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Areas in thousands of square kilometres

Fig. 2. Areas and capacities of the depression at levels corresponding to different depths below sea-level. From 40 metres below sea downwards, the area-curve is seen to be very approximately equivalent to the four dotted straight lines

metres, and a fourth when l is between 60 and 40 metres below sea, the actual values of α and β, as derived from the plotted diagram, being:

	α	β
For all levels between 134 and 90 metres below sea	2·4	0·018
,, ,, ,, 90 ,, 70 ,, ,,	35·9	0·390
,, ,, ,, 70 ,, 60 ,, ,,	33·1	0·350
,, ,, ,, 60 ,, 40 ,, ,,	20·2	0·135

The expression for t found above thus becomes $t=\int_{l_2}^{l_1}\frac{dl(\alpha-\beta l)}{I/(\alpha-\beta l)-E}$, the evaluation of which gives, after reduction and conversion of hyperbolic into common logarithms,

$$t=\frac{2\cdot3026I}{E^2\beta}\log\left[\frac{I-E\alpha+E\beta l_1}{I-E\alpha+E\beta l_2}\right]-\frac{l_1-l_2}{E}$$

from which formula, using the values already found for I, E, α, and β for the various lakes and levels (and of course allowing for the variations in the values of α and β by performing the calculation in as many separate stages as may be necessary) we can find the times in years which would elapse from the

first admission of sea-water into the depression to the attainment of various levels by the lakes. Fig. 3 exhibits graphically the results of a series of such calculations for lakes whose final levels are to be 50, 60, and 70 metres below sea, on the supposition that the full permissible influx is admitted from the start, and also for a lake of final level 50 metres below sea on the alternative supposition that only one-third of the total permissible influx is admitted during

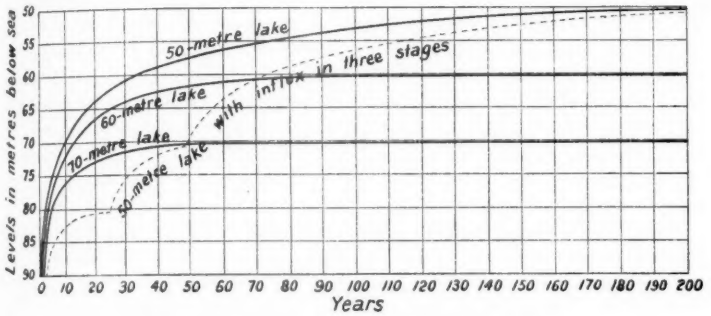


Fig. 3. Progressive rise of water-levels in lakes

the first twenty-five years, two-thirds during the next twenty-five years, and the full permissible influx thereafter.

It will be evident from the curves in Fig. 3 that while the levels of all the lakes would at first rise somewhat rapidly, the rates of rise would gradually diminish, and would become exceedingly slow as the lakes neared their final

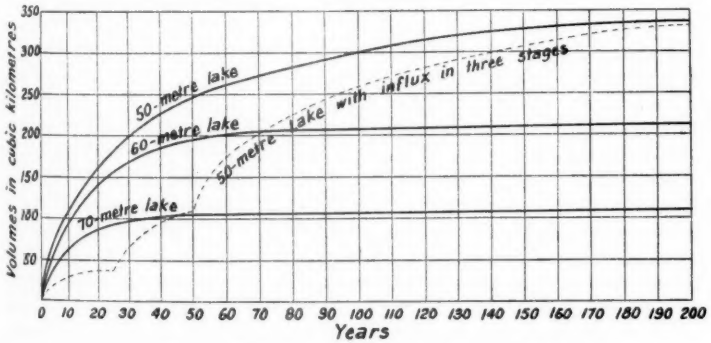


Fig. 4. Progressive increase in volume of lakes

levels. In fact, strictly speaking, the lakes would only attain their final levels after the lapse of an infinitely long period; for as the lake-surfaces more and more nearly approached their final levels, the quantities of water removed by evaporation during any period would approximate more and more nearly to those entering during the same period from the sea, and would ultimately be equal to them; that is, the rates of rise of the lake-surfaces would ultimately

become infinitely slow. Lakes whose final levels were to be 50, 60, and 70 metres below sea, and into which the full permissible influx was admitted from the commencement, would still be a metre below their final levels after periods of 150, 60, and 38 years respectively. If there were no evaporation at all, these levels would be reached, with the same rates of influx, in about 16, 11, and 9 years respectively.

In the case of the 50-metre lake with only one-third of the full permissible influx admitted during the first twenty-five years, two-thirds during the next twenty-five years, and the full influx thereafter, the curves show that at the end of the first twenty-five-year period the lake-level would have become nearly stationary at about 80 metres below sea-level; it would then rise, and again become nearly stationary at about 71 metres below sea at the end of the second twenty-five-year period; after which it would again rise, and would reach to within a metre of its final level about 190 years after the first admission of water into the depression.

The progressive increases in volume of the lakes can be readily traced when once the progressive rises in their levels have been determined; for to ascertain the volume of a lake at any time t from the start, we have only to note from the curve in Fig. 3 the level to which the lake would then have attained, and then to find the capacity of the depression at the corresponding contour-level, which we can easily do either by reference to the capacity-curve in Fig. 2 or by a larger-scale graphic interpolation between the capacities given at various contour-levels in the table on p. 293. Fig. 4 exhibits the progressive increases in the volumes of the lakes as found in this way, corresponding with the rises of level shown in Fig. 3.

Progressive increase in salinity of lakes

The salinity (in terms of that of sea-water) of a lake at any period of its existence up to that of the commencement of deposition of salt on its floor will obviously be given by the simple proportion: total volume of water passed into lake to volume of water remaining in lake; or, putting S for the salinity (sea-water=1), I for the annual influx in cubic kilometres from the sea into the lake, and v_t for the volume of the lake at the time t in years after the commencement of its formation as given by the graph in Fig. 4, $S=It/v_t$. The salinities of the various lakes after various periods of their existence as calculated by this formula are shown in Fig. 5, from which it will be noticed that if the full permissible influx were to be admitted from the start, lakes whose final levels were to be 50, 60, and 70 metres below sea would acquire a tenfold degree of salinity after about 160, 120, and 100 years respectively; while in the case of the 50-metre lake with influx admitted in the three stages above mentioned, the salinity would increase in the first twenty-five years to about 4·2, then fall to about 3·7 during the next ten years, then rise to about 5·0 at the end of the second twenty-five years, then again fall to about 4·2 during the next ten years, after which it would rise continuously, ultimately attaining a tenfold degree after the lapse of about 180 years from the commencement of the influx.

When the tenfold degree of salinity had been reached, the lake would consist of saturated brine, and salt would begin to be deposited on its floor. The

salinity of the lake would thereafter remain constant for a very long period, salt being deposited at such a rate as would just balance that at which fresh quantities of it were being brought into the lake from the sea. From the experiments of Usiglio[1] it appears that when a litre of Mediterranean sea-water (containing about 37·7 grammes of dissolved salts) is subjected to evaporation until 96·1 per cent. of the volume of water has disappeared, the salts remaining in solution only amount to 14·8 grammes out of the original 37·7, the rest having been deposited; so that the salinity is still only about ten times that of sea-water, although twenty-five times as great a volume of water has been evaporated as now remains. Hence even after twenty-five times as much sea-water has passed into the lake as remained in it, that is, in the case of a 50-metre lake, after about four hundred years from the start, the

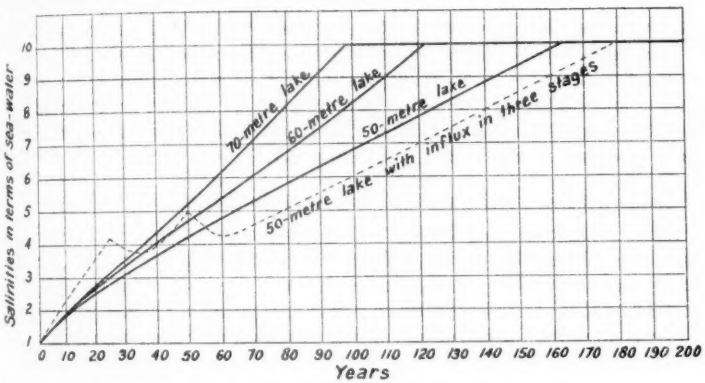


Fig. 5. Progressive increase in salinity of lakes

lake would still only have about the same degree of salinity as it had when salt first commenced to be deposited in it.

Eventual salting-up of lakes

There would however eventually come a time when the lake would be entirely salted up. To obtain some idea of when this salting-up would occur, let us assume the density of the actual salts contained in sea-water to be 2·2 times that of sea-water itself, which is known to be very nearly the case. Then since Mediterranean sea-water contains 3·77 per cent. by weight of dissolved salts, 220 volumes of sea-water will have to evaporate to produce 3·77 volumes of deposited salt. If V is the volume of the lake, supposed now to be entirely occupied by salt, the total volume of water which must have been evaporated from the lake is $220V/3{\cdot}77$, or $58V$; and if I_m has been the average annual influx into the lake, then the time in years during which the influx has lasted is $58V/I_m$. To have maintained a constant level in the lake, the average rate of influx over the whole period from the first admission of sea-water into the depression to the complete salting-up of the lake will, of course, have had

[1] *Annales de Chimie et de Phys.* (3), vol. 27, p. 172; quoted in Bischof's 'Chemical and Physical Geology,' London 1854, vol. i, pp. 105, 361.

to be somewhat lower than that during the first century of the lake's existence, in order to balance the lessening rate of evaporation due to increasing salinity, and also to compensate for the reduction of the area exposed to evaporation by the deposition of salt around the borders of the lake towards the end of the period. We may suppose that the average rate of influx I_m for the whole period will have been about three-quarters of the rate I which was found above for the average permissible rate of influx during the first century of the lake's existence, or, say, $I_m = 16$, 13, and 8 cubic kilometres per year for lakes at 50, 60, and 70 metres below sea respectively. Then the capacities of the depression at these levels being respectively 340, 212, and 108 cubic kilometres, we have, for the approximate time which would elapse to the complete salting-up of the lake at 50 metres below sea, $58 \times 340/16$, or, say, 1230 years; and by a similar process of calculation, 940 and 780 years for the approximate periods of complete salting-up of lakes at 60 and 70 metres below sea respectively.

Vast as these periods are, they still fall short of representing the full duration of the power-resources of the depression; for by merely moving the power-station successively to somewhat higher levels as the salt accumulated, the installation could be given further long leases of life, though of course with some lowering of power-output at each removal.

Amounts of power developable with lakes at different levels

Since a kilowatt is equivalent to 102 kilogramme-metres per second, the gross rate of evolution of energy from Q cubic metres per second of sea-water of density 1·025 falling through a height of H metres will be $1025QH/102$; and taking the values of Q found on p. 299, this gives us 330,000, 328,000, and 240,000 kilowatts for the gross rates of evolution of energy with lakes at 50, 60, and 70 metres below sea respectively. Of this total energy however a considerable proportion would be lost in the conduits and in the generating-plant; and it will be shown later that under the condition of due regard being paid to constructional costs, the proportion so lost would in each case be somewhere about 40 per cent., leaving only some 60 per cent. or so of the gross energy for available output. The developable net outputs at the generating stations would thus be roughly about six-tenths of the above figures, or, say, 200,000 kilowatts with the lake at 50 or 60 metres, and 150,000 kilowatts with the lake at 70 metres below sea-level.

What would be the best lake-level for power-generation?

The best lake-level to adopt for the power-scheme would not necessarily be the one which would yield the greatest output of power at the generating-station, but rather the one which, while permitting of a relatively large power-output at the generating station being combined with relatively small transmission losses between the generating station and the Delta, would entail the smallest capital outlay per kilowatt on works of construction. The question of which lake-level to choose is thus rather a complicated one, depending on a number of engineering and other considerations, fully adequate data concerning some of which are still lacking. By a careful study of such data as are now available to us however we may succeed in narrowing down the issue, and in obtaining at the same time a clear indication as to what further investigations

should be undertaken in order to furnish the additional information needed for a final solution of the problem.

We shall begin by considering the size and slope of the conduits which would be necessary to convey the influx from the sea to the various lakes; and there are three very important natural factors which will greatly limit the scope of our inquiries in this direction. These three natural factors are, firstly, the very large quantities of water to be conveyed, namely 656, 546, and 348 cubic metres per second for lakes at 50, 60, and 70 metres below sea respectively, which will necessitate large sectional areas for the conduits; secondly, the great distances to be traversed by the conduits (70, 76, and 80 kilometres) in proportion to the total falls of 50, 60, and 70 metres respectively available, which will restrict us to small degrees of slope, and therefore to comparatively low velocities of flow; and thirdly, the great height of the tract intervening between the sea and the depression, which will render it necessary for at least two-thirds of the lengths of the conduits to consist of tunnels, to the practicable diameter of which there must of course be a limit.

It is easy to see from the figures just mentioned that a single tunnel to convey the whole permissible influx to any one of the three lakes would have to be of exceedingly large diameter. In the case of the 50-metre lake, for instance, even if we were prepared to sacrifice as much as three-eighths of the total fall in giving slope to the conduits, the fall in the latter would only be 19 metres in 70 kilometres, or say 27 centimetres per kilometre; and a circular tunnel to pass 656 cubic metres per second (which by the way is a quantity greater than the average summer discharge of the Nile) with this degree of slope would need to be at least 17·3 metres, or nearly 58 feet, in diameter. So large a tunnel as this would probably be quite impracticable; even if it were practicable, it would be very expensive to construct; and it would present the three further serious disadvantages that the whole outlay involved in its construction would have to be expended before there could be any return on the capital, the power available from it would most probably be considerably in excess of the immediate demand, and periodical inspection of its interior would not be possible without temporary suspension of the entire output. The division of the influx between at least two tunnels thus appears to be imperative; and *three* tunnels would probably be better still, as not only bringing the necessary diameters down to within practicable limits, but also diminishing the initial capital outlay (since only one of the three tunnels need at first be constructed, and would probably suffice for initial power-requirements), and eventually permitting of inspection of the interior of the tunnels being carried out without the temporary suspension of more than one-third of the total power-output.

In calculating the power-outputs which would be available with different slopes (and correspondingly different diameters) for the conduits to the various lakes therefore, we shall assume that the tunnelled portion of each conduit will consist of three tunnels of equal diameter, while the open part of the conduit may be a single canal. We shall further assume the tunnels to be circular in cross-section, lined with concrete neatly faced with cement, running full; the relation between velocity of flow and slope to be in accordance with the equation of Hazen and Williams, $v = 1{\cdot}32 C r^{0{\cdot}63} s^{0{\cdot}54}$, where v is the velocity in feet per second, r the hydraulic mean radius in feet (=one-fourth of the diameter in

feet for circular tunnels), s the slope, and C a constant having the value 140 for concrete-lined tunnels of good workmanship[1]; the total lengths of the conduits to be equal to the shortest distances from the coast to the respective final lake-level contours (which can be very nearly the case in actuality); the slope of the open-canal portion of the conduit to be the same as that of its tunnelled portion; and the overall efficiency of the generating plant to be 0·75.

The equation of Hazen and Williams above mentioned can be written in the form $D^{4\cdot87}=105\cdot5Q^{1\cdot85}/f$, where D is the diameter of the tunnel in metres, Q the discharge in millions of cubic metres per day, and f the slope expressed in metres per kilometre. The graphs in Fig. 6 show the results of applying this transformation of Hazen and Williams's equation to calculate the diameters in metres required for each of three tunnels discharging one-third of the total permissible influx into the three lakes with different slopes, and the corresponding velocities of flow in metres per second in each case.

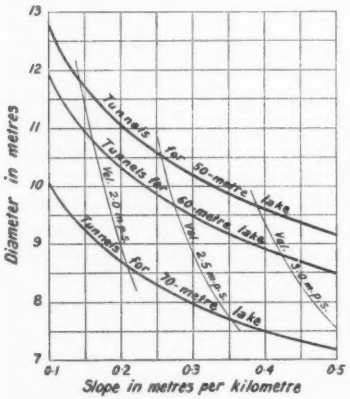


Fig. 6. Relation between slope, diameter, and velocity of flow in three equal circular tunnels each discharging one-third of the total permissible influx into lakes at 50, 60, and 70 metres below sea-level, as calculated from Hazen and Williams's equation

The slopes required for tunnels of different diameters to pass the influx into each of the three lakes being thus known, it is easy to calculate the effective power-outputs which would be derivable with various diameters of tunnels in the three cases, since the energy which would be available at the power station will be to the gross energy in the proportion of $0\cdot75(H-fL)$ to H, where H is the total fall from the sea to the lake-level, f the slope in metres per kilometre, and L the total length of the conduit in kilometres. The results of a series of such calculations are shown graphically in Fig. 7.

If now we make the further assumption that the relative costs of the conduits to the three lakes will be proportional to the products of the cross-sectional areas of the tunnels into the respective total lengths of the conduits (which will probably be approximately true provided that the difficulties presented by the ground to tunnelling operations are similar in the three cases and the diameters do not vary over too large a range), we can go a step farther and calculate the relations between effective power-output and cost of conduit per unit of output in the three cases, using as our formula:

$$\text{relative cost of conduit per unit of power-output}=\tfrac{3}{4}\pi LD^2H/P(H-fL)$$

[1] It may be remarked that throughout the range with which we are concerned, the results derived from Hazen and Williams's equation are very nearly the same as would result from the Ganguillet-Kutter equation with a roughness-coefficient of 0·0115, a value which has been found to agree very well with observation in well-constructed cement-lined tunnels in Switzerland (see Buchi, *Schweiz. Bauzeitung*, Band 90 (1927), pp. 163–165).

where P is the gross rate of evolution of energy corresponding to the total permissible influx and total fall for any particular lake as found above, and L, D, H, and f have the same significations as before. The graphs in Fig. 8 exhibit the results of a number of such calculations. It will be seen that on the assumptions made, the cost of conduit construction per unit of power would be lowest in the case of the 70-metre lake; but the difference in that respect between the 70-metre and the 60-metre lakes is only about 3 per cent., while the amount of power obtainable from the 60-metre lake is very considerably greater. For the 50-metre lake the cost of conduit construction per unit of power would (on the assumptions made) be about 9 per cent. higher than that

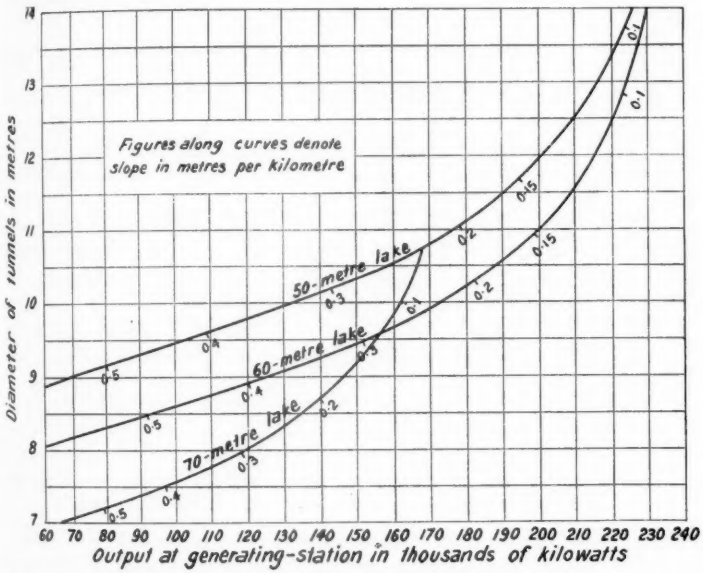


Fig. 7. Relation between total effective power-output, diameter, and slope for three equal circular tunnels each discharging one-third of the total permissible influx into lakes at 50, 60, and 70 metres below sea-level

for the 60-metre lake, while the amount of power obtainable would be only about the same. It will also be noticed from the graphs that with both the 50-metre and 60-metre lakes the lowest cost of conduit construction per unit of output would be achieved with an output at the generating station of about 175,000 kilowatts; but in each case the extra cost per unit for an output of 200,000 kilowatts would be only some 5 per cent. higher. For an output of 175,000 kilowatts at the generating station the three tunnels would have to be each about 11 metres in clear diameter for the 50-metre lake and about 10 metres in diameter for the 60-metre lake; while for an output of 200,000 kilowatts the diameters would need to be about a metre larger in each case.

It is thus apparent that if the ground to be traversed by the conduits were

similar in the three cases, and low cost of conduit construction combined with high output at the generating station were the only thing to be considered, the 60-metre lake would be the best to select, more especially when it is remarked that the actual diameters of the tunnels with the 60-metre lake would be about a metre less than with the 50-metre lake.

But there is also the factor of the lengths of the transmission lines from the power stations to the Delta in the two cases to be considered, and it will be seen from the table on p. 293 that the approximate distance from Tanta to the power station of the 60-metre lake would be 280 kilometres, against 247 for the 50-metre lake. The 50-metre lake thus presents an advantage of about 12 per cent. over the 60-metre lake as regards the length of main transmission line.

When we reflect that the 9 per cent. or so in greater cost of the conduit per

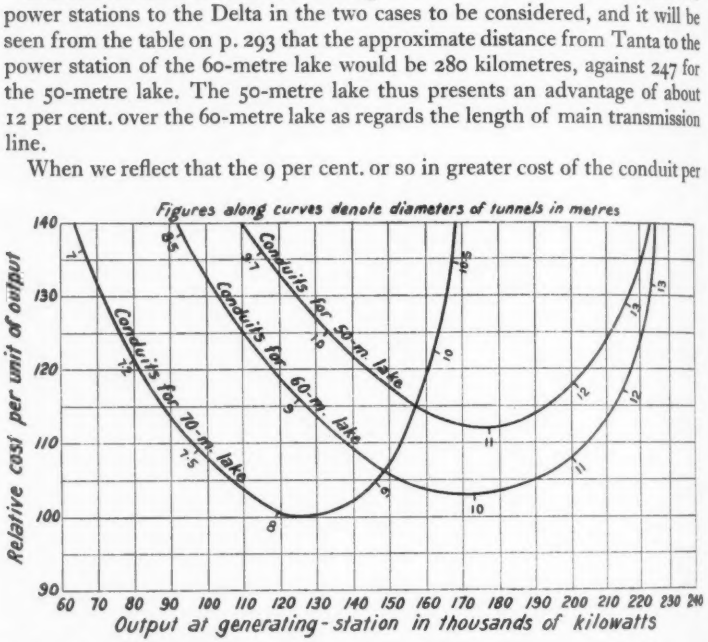

Figures along curves denote diameters of tunnels in metres
Relative cost per unit of output
Output at generating-station in thousands of kilowatts
Conduits for 70-m. lake
Conduits for 60-m. lake
Conduits for 50-m. lake
140
130
120
110
100
90
60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240

Fig. 8. Graphs showing total effective power-outputs, approximate relative costs of conduit-construction per unit of effective output, and diameters of three equal circular tunnels each discharging one-third of the total permissible influx into lakes at 50, 60, and 70 metres below sea-level

unit of output for the 50-metre lake would affect only the initial expenditure, while the 33 kilometres of greater distance between the power station and the Delta for the 60-metre lake would entail not only the extra initial outlay and maintenance costs required for this greater length of transmission line and of railway or other communication between the Delta and the power station, but also some diminution in the amount of power which could be made continuously available in the Delta owing to the somewhat greater loss which would result from the longer transmission distance, there does not appear to be a very decided balance of advantage for either lake over the other; and we may well leave the final selection between them to depend on the results of geological and other investigations as to the nature of the ground which would have to be traversed by the conduits in the two cases, the underground water

conditions, and the relative lengths of open canal and tunnelling which would be necessary. Up to the present, such geological and other investigations have been practically confined to the line which appears to be the best for a conduit to the 50-metre lake; and in the following sections the results of these investigations will be briefly set down.

Nature of strata which would be traversed by the conduits

The line chosen for a detailed investigation of the underground structure of the tract between the sea and the depression is that marked "Line D" on the map. The distance along this line from the coast to the −50-metre contour of the depression is about 72 kilometres, thus exceeding the shortest distance by some 2 kilometres; but the line was selected as being probably that best suited for the conduit. Following this line, the conduit would leave the coast at a point about 8 kilometres north-west of the little railway station of Alamein (where the shore is composed of soft limestone rock), and, running in a direction about 33° west of south, would pass beneath the prominent headland called Mingar Budweis to enter the depression. (It was considered that the strata would be less likely to be disturbed by local faulting beneath the headland than elsewhere.) A carefully levelled section was taken over the line, and trial borings were put down along it, mostly about 5 kilometres apart, penetrating where possible to depths slightly below those at which the conduit would pass. The rocks passed through by the borings were limestones, marls, sandstones, clays, and sands, the last two predominating at the lower levels. With borings so far apart, and many alternations in the strata passed through, the correlation of the beds in the different borings was necessarily somewhat uncertain; but the section in Fig. 9, in which minor variations in the beds have of course had to be omitted owing to the smallness of the scale, represents what appears to me to be the most likely interpretation of the general structure. It should be remarked that owing to the magnification of the vertical scale as compared with the horizontal, the inclinations of the strata appear greatly exaggerated in the figure, the actual inclination of the beds to the horizontal probably nowhere exceeding half a degree. The limestones and sandstones are mostly rather soft in character, and the clays are mostly compact, though sometimes finely laminated and containing occasional thin sand partings. The sands as brought up in the cores were usually quite loose; but this looseness was doubtless largely due to the effect of the drill itself, for in a small shaft which had to be sunk alongside one of the bores in order to get at some broken tools, it was found that the sand passed through was well compacted, although that brought up by the drill from the same stratum had appeared quite loose. There was no certain evidence from the borings that *running* sand would anywhere be encountered in the tunnelling operations. Near the foot of the escarpment-face, within the depression, some of the outcropping beds of sand appear very loose, but this may possibly be due to disintegration by weathering at the exposed surface, which faces due south and is thus subjected to large diurnal variations of temperature. It is much to be desired, of course, that the degree of consolidation of the sands which would be traversed by the tunnels should be carefully tested by sinking shafts at a number of points and by driving headings into the face of the escarpment. Incidentally, the section shows the general

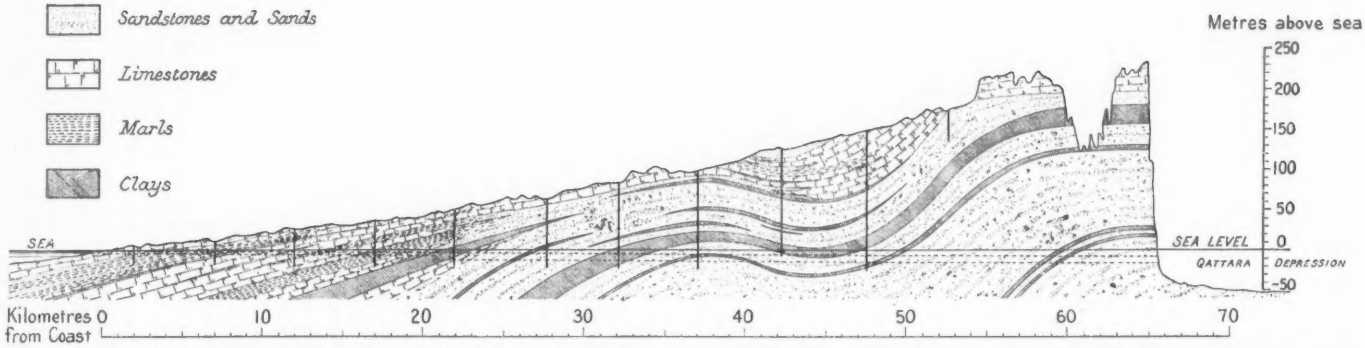


Fig. 9. Geological section along the line marked D on the folding map, showing the probable underground structure as deduced from trial borings. Vertical scale magnified 200 times. The thick vertical lines indicate the trial borings, the dotted lines the course of the proposed canal and tunnels

nature of the rocks through which working shafts would have to be sunk in connection with the driving of tunnels.

Particular interest attaches to the distribution of underground water as revealed by the trial borings. In the borings up to 17 kilometres from the coast, the underground water-level was found to be practically that of the sea; at 22 kilometres from the coast it had sunk to 14·4 metres below sea-level; and at greater distances from the coast all the borings were quite dry down to the full depths reached (22 to 28 metres below sea-level). The geological section informs us as to the reason for this; the thick bed of impermeable clay which dips to the north so as to pass below sea-level at about 20 kilometres from the coast effectually prevents the infiltration of sea-water from extending farther southwards.

Before deciding on the line along which to carry out the trial borings, a careful search was made to see whether a suitable natural ponding-site could be found within the depression at or near the point of emergence of the tunnels, as a provision for dealing with diurnal variations of load while keeping the flow through the tunnels constantly at or near the full rate of discharge. But it was found that the ground was composed of very porous sandstones for a considerable distance on either side of the foot of the headland, and the hope of finding such a site in connection with the conduit for the 50-metre lake was therefore reluctantly abandoned. There still remains, of course, the possibility of hydraulic storage by using the surplus power at times of slack load to pump a part of the inflowing water into a high-level reservoir on the top of the escarpment, and then utilizing the 200 odd metres of fall to work supplementary high-pressure turbines during times of peak load. But the energy losses would naturally be then greater than would result from simple ponding at the outfall-level. (In this connection it is worth noting that farther to the west, in the neighbourhood of where lines E and F enter the depression, the beds forming the foot of the scarp are typically more clayey in character; so that it is not impossible that a ponding-site might be found in connection with the conduit for a 60-metre or 70-metre lake.)

Proportions of tunnels and open canal

At the place where the conduit for the 50-metre lake (Line D) would have its intake from the sea, the sea-floor appears to be formed of soft oolitic limestone and calcareous sand; it has a very gentle slope, reaching a depth of 2 metres at a distance of about 60 metres from the shore, and 4 metres at about 400 metres. The amplitude of the tidal rise and fall of the sea-level is very small, being less than a foot at springs; but somewhat larger irregular oscillations are caused by winds. So far as could be observed, there is no systematic drift along the coast in either direction in this locality.

For the first 2 kilometres of its length the conduit would traverse very low-lying ground, and would of course be a canal running between banks made from the spoil. Farther inland however the ground rises with an average upward slope of rather less than 2 metres per kilometre, and consists for the first 20 kilometres or so mainly of soft limestones and marls, with some sands and clays (see the section in Fig. 9); the construction of the canal would thus entail progressively deeper and deeper cutting with increase of distance from the coast.

The distance from the coast at which tunnelling would prove to be less expensive than an open canal would probably be determined as much by the underground water conditions as by the rise of the ground-levels. From the above-mentioned evidences as to the underground water-levels obtained in trial borings along the line proposed for the conduit to the 50-metre lake, it may be inferred that beyond a point about 20 kilometres inland no underground water would be encountered in the excavation of the conduit; and bearing in mind the much heavier cost of tunnelling in the presence of underground water as compared with that of tunnelling in the dry, the idea naturally suggests itself to form the first 20 kilometres or so of the conduit by an open canal, and to tunnel the remainder of the distance to the edge of the depression. A 20-kilometre length for the open canal would however entail a very considerable cube of excavation, for the ground rises to 34 metres above sea-level at 20 kilometres inland, and even to levels a few metres higher than this in some intermediate parts of the 20-kilometre stretch. Assuming the length of the canal to be 20 kilometres, the depth of water to be 4 metres, the fall to be about 16 centimetres per kilometre, the side slopes of the waterway to be 1 to 1, the cutting to be benched for a width of 5 metres on each side at 1 metre above the water-level, and the side slopes of the cutting above the bench-level to be 2 vertical to 1 horizontal (which seems likely to be a practicable average slope for the rocks which would be traversed by the cutting), an estimation by measurement from the levelled section gives the total amount of excavation required for the cutting and canal as about $16+0{\cdot}55w$ million cubic metres, where w is the bed-width in metres adopted for the canal.

To discharge 656 cubic metres per second (the full permissible influx into the 50-metre lake), a canal of the above section and slope would need to have a bed-width of at least 75 metres, so that the total volume of excavation for it would be about $16+41$, or 57 million cubic metres. Of course if the scheme were proceeded with in stages, the initial canal need not have this full width; for a bed-width of 25 metres the volume of excavation works out at about 30 million cubic metres.

If the first 20 kilometres of the conduit to the 50-metre lake were made an open canal, the distance to be tunnelled would be about $45\frac{1}{2}$ kilometres. Three tunnels would be required, of about 11 metres clear diameter for an output of 175,000 kilowatts at the generating station, or about 12 metres for an output of 200,000 kilowatts.

Beyond the point where the tunnels would emerge into the depression, there is sloping sandy ground for a distance of about $6\frac{1}{2}$ kilometres to the -50-metre contour. It would perhaps be practicable to place the power station in a sunk position near the foot of the scarp, with an open cut discharging to a point below the 50-metre contour.

In regard to the relative lengths of canal and tunnelling which would be requisite for conduits 76 and 80 kilometres long following the lines E and F to lakes at 60 and 70 metres below sea respectively, no detailed investigations have been made; but from the general configuration of the ground it appears probable that the proportion of tunnel to open canal would be somewhat greater along both these lines than along that to the 50-metre lake. The volumes of excavation for equivalent lengths of canal would however be less

than in the case of the canal for the 50-metre lake, because the quantities of water to be conveyed would not be so large.

Economic aspects

The question as to whether the utilization of the depression for power generation is to be recommended on economic grounds must, of course, turn chiefly on the outlook with regard to prospective future demands for power for various purposes in Lower Egypt, and on the cost of producing power in this way as compared with that of either generating it at the newly heightened Aswan Dam and transmitting it over the 900 kilometres (560 miles) of distance to the Delta, or generating it by means of fuel-consuming plant at sites near to those of its application. A discussion of this question is beyond the scope of the present paper. But it will be abundantly evident from what has been said that the principal item of expense in any scheme for the utilization of the depression for power purposes would be the construction of the necessary conduits for the passage of sea-water to it from the Mediterranean; and the following tabular summary of some of the main conclusions reached in regard to the leading data for some possible alternative schemes of power-production from the depression may perhaps be of some aid towards enabling a rough estimate to be formed as to the constructional outlay which such schemes would involve.

Summary of Data for Alternative Schemes

Lake-level below sea-level	metres	50	60	70
Length of conduit from sea to contour ..	km.	72	*c.* 76	*c.* 80
Open canal from sea to tunnels [1]	km.	20		
Excavation for open canal	cu. m.	57×10^6		
Length of 3 tunnels, each	km.	45·5		
Cutting from tunnels to contour ..	km.	6·5		
Transmission distance to Tanta	km.	247	280	312
Diameter of tunnels for 200,000 kw. ..	m.	12·0	11·0	—
175,000 kw. ..		11·0	10·0	—
150,000 kw. ..		10·3	9·5	9·2
125,000 kw. ..		9·8	9·0	8·2

It should be noted that on the basis of the adopted figures for evaporation, etc., the various power-outputs could be maintained at the full tabulated rates for at least a century, and at slowly diminishing rates for many centuries thereafter; also that in each case the scheme could very conveniently be carried out in three successive stages, to keep pace with the demand for power. It is further worthy of remark that a moderate amount of error in the assumed rate of evaporation would not affect the power-output developable during the first two stages of the operation of any scheme. It is doubtful whether preliminary tank experiments in the depression itself would yield much more reliable values for the rates of evaporation from an open lake of varying salinity than the data from the Birket el Qarun and the Karabugas on which my estimates of permissible influx and developable power-output have been based; but very

[1] It has here been assumed that the open canal would traverse the whole of the stretch along which underground water would be encountered, so as to confine the tunnelling to dry ground. But in view of the great depth and volume of open excavation which this would entail, it is quite possible that it would be found less expensive to make the canal shorter and the tunnels correspondingly longer, facing whatever water-difficulties might be met with in driving the initial portion of the latter.

accurate values for the rates of evaporation would be readily derivable from observations of the actual lake-levels during the first and second of the three stages of operation of any scheme; and the diameter of the third tunnel could then be made larger or smaller than those of the first two, by the amount required to enable it to convey the balance of the permissible influx as deduced from the lake observations.

As mentioned above, under the headings of Rainfall and Inward Seepage, the formation of a salt-lake of considerable size within the depression would most probably bring about a small but perceptible increase of rainfall over the desert surrounding the depression, and also a sensible rise of the static water-levels in the oases to the south of it. Both these effects would result in benefits to the country additional to those derivable from the power-production itself. Even a small increase in the rainfall on the plateau between the depression and the sea would be of some advantage to the littoral agriculture; and a rise of only a few metres in the static water-levels of the oases of Bahariya, Farafra, Kharga, and Dakhla would enable the cultivated areas in these places to be considerably augmented, by reason of the increased outflow which would be obtainable from the wells. It is however impossible to forecast what the ultimate magnitude of these incidental effects would be, and it is tolerably certain that they would not begin to be very sensible in amount until after the lapse of a considerable period, owing to the time which would be occupied in the attainment of the final area and level of the lake. From the point of view of an early economic return on the capital outlay for power-production therefore these prospective additional benefits may possibly appear to be scarcely worth taking into account. But they are benefits of a kind which it is difficult to think of as being practicable of obtainment in any other way; and for that reason, if for no other, they should not be entirely overlooked in any comparison between the depression and alternative sources of power.

Another matter which might perhaps be found worth taking into consideration along with the development of power is the possibility of commercially exploiting salt in the depression. With the full permissible influx for a lake whose final level was to be 50 metres below that of the sea, salt would be entering the depression continuously at the rate of about 2 million tons a day; and although none of this salt would be deposited in the lake itself till after the lapse of some 160 years, it might be practicable to exploit part of it from the very commencement, by causing a portion of the sea-water discharged from the turbines to flow into large shallow pans and evaporate there, instead of allowing it all to pass into the lake. The possibility of doing this cheaply would depend on whether a suitable tract of impermeable ground for the pans could be found near the path taken by the discharge on its way to the lake, the advancing shore of which would of course for a long period be at a considerable distance from the power station. The area over which the discharge-water would naturally take its way is at present mostly covered with salt-marsh, so that an examination of the ground itself is difficult; but when once the discharge-stream had established its course, the higher-lying parts of the present marsh would doubtless be automatically drained by the stream, and it is, I think, not unlikely that a suitable stretch of impermeable ground might then be found at no great distance from the power station.

THE MOUNTAINS OF NORTHERN LABRADOR: *Continuation from the September Journal of a paper read at the Evening Meeting of the Society on 7 November 1932, by*

N. E. ODELL

The Northern Torngats

The aerial part of the survey being practically completed, and word being received by wireless that neither fuel for the *Ramah* nor petrol for the planes had been delivered at Hebron, plans for the future had necessarily to be modified. On completion of their work the aerial section were to depart southward, and on August 9 the *Ramah* sailed northward to extend the triangulation and geological and botanical reconnaissances.

A brief visit was made to Ryan's Bay, one of the grandest openings on the coast, which skirts the northern side of the "Four Peaks" Group.[1] Here we were welcomed by some encamped Eskimos numbering eleven, living in two tents, who came from the Eclipse Harbour neighbourhood to the north. To our surprise and gratification, on being shown some of our aerial photographs they identified and named for us certain features along the coast: the whole transaction was a remarkable demonstration of signs and wonders in view of our party's complete ignorance of the Eskimo language! The state of the weather and shortage of time forbade more than a brief stay, but some useful theodolite intersections, and other reconnaissances ashore, as well as an evening run to the end of this extraordinarily beautiful bay by motor boat, were duly accomplished. The "Four Peaks," seen from this side, are a fine group and would well repay further investigation of their bold peaks and deep glacier-filled corries by a party of mountaineers. It was a regret that circumstances prevented our ascending more than one peak of the group from Kangalaksiorvik. As already mentioned, it seems that no peaks in this group exceed 4415 feet in altitude, and therefore the claim by earlier visitors to this part of the coast that they attain as much as twice this elevation, and are therefore the highest summits on the Atlantic seaboard of America, must be considered a tribute to their fine forms and proportions. Miller's computations have not so far revealed that any crests of the Torngats exceed 5000 feet.

The prevailing formations on the north-western side of Ryan's Bay, where visited, were hornblende gneiss, veined by amphibolite and pegmatite, and striking nearly north and south. The spectacular peaks of the Northern Range, which we viewed from a divide leading over to Eclipse Harbour, showed many fine crests sharply chiselled out of these metamorphic rocks. Our progress on up the coast gave us glimpses of this same range, which is in reality the northward extension of the "Four Peaks" Group, in the fine forms around Eclipse Harbour itself and especially Big Bay. On the southern side of the latter are the remarkable "Castle Mountain" and other peaks referred to by Grenfell: steep-sided, flat-topped forms, reminiscent of the coastal tinds of Northern Norway, and displaying portions of the dissected and truncated border of the same old erosion-surface previously described.[2] We sailed on

[1] The very appropriate name for Ryan's Bay we understood from our local Eskimo informants to be Kongokulluk, meaning "cleft in the rock."

[2] W. T. Grenfell and others, 'Labrador,' p. 59, and fig. 4.

past Cape Kakkiviak and the sombre cliffs of Black Rock Point, having found Sir Wilfred's deep passage inshore and keeping a constant masthead look-out for shoals, as well as deriving assistance from aerial photographs already taken and developed at Seaplane Cove. The photographs had revealed, as they did farther south, a great many discrepancies and deficiencies between the map and nature. On the top of Cape Kikkiviak a trigonometrical station was established which was of importance in the northern triangulation and served to tie it in to the net already carried out farther south.

We now entered the largest opening on the extreme north-eastern coast, for which no appropriate or correctly applied name would seem to exist,[1] and found excellent anchorage in a sheltered bay on its eastern side on August 11. Next day a violent and remarkably warm wind blew from the westward, and if it were not for the relatively low altitude of the hills in that direction and the number of almost sea-level gaps in this narrowed and diminished portion of the Northern Range, one would have been inclined to attribute the effect to true adiabatic heating and regard it as a veritable chinook, or föhn, wind.

Coleman (p. 11) has described, as already mentioned, the prevalence of what he regarded as chinook winds farther south where the mountains are higher, and such in small degree may very well be the case. The conditions for chinook however in the north seemed to be absent, and the veering of the wind, the arrival of rain, and the prevailing barometric changes suggested merely the passage eastward in the neighbourhood of Hudson Strait of a deep secondary depression. One benefit experienced as the result of the strong wind was the complete disappearance of the mosquitoes, but on its lulling they recommenced their activities and followed us even to the tops of the mountains.

This northern district, and indeed all the northern parts of the peninsula, are of much less pronounced topography, and of more barren aspect, than farther south, and there is an openness about the country in strong contrast to the latter. Our explorations here revealed the same metamorphic formations in general, garnet-rich gneisses in predominance, and widespread evidence of continental glaciation. It was of particular interest to find on summits and open areas free of the constraining influence of the valleys, that striations, furrows, roches moutonnées, etc., indicated a movement mainly towards east-north-east, though it would also appear that the ice-sheet had a direction nearer to north-east during part, and probably the earlier and maximum phase, of its existence. This would indicate a centre of radiation considerably northward of where Low has suggested for it during its later stages from evidence in the far interior, *i.e.* more in the neighbourhood of the headwaters of the Koksoak River, or even farther north, than between latitudes 53° and 55° in the centre of the peninsula, as he has surmised. Low was however of the opinion that the centre of glaciation shifted its position progressively northward, and the above evidence conforms to such a thesis.

Having explored the eastern side of the fjord, on August 14 in brilliant

[1] The name Tessiujarsuk, meaning salt-water lagoon, is placed near this feature on the Admiralty Chart, but is obviously an inappropriate misnomer. Ikordlearsuk, incorrectly spelt Ekortiarsuk on the chart, according to Mr. Perrett, of Hopedale, and meaning "the place where the reindeer swim across," would seem to apply to the narrowing of the fjord in its southern portion, and not to the whole feature.

Entrance to Ryan's Bay; mist forming over flow-lines of the Labrador Current

(The full-page plates are reproduced by permission of the Grenfell-Forbes Northern Labrador Expedition)

Southern section of the Northern Range, near the south end of Eclipse Harbour

sunshine four of us were ferried in the speed-boat across the 4 miles separating us from the mountainous western shore, and found a landing a short way up an extensive branch-fjord, on its northern side. A rough ascent brought us to a tarn about 1000 feet above the fjord, and thence an excellent stretch of rock-climbing enabled us to reach a flat-topped summit, whose southern precipices fell abruptly from 2250 feet to the sea. Of interest here was the presence of weathered and pitted slabs with signs of glacial polish still remaining and extensive areas of frost-riven material. Pushing on northward over the summit we descended to a formerly glaciated col at 1800 feet, where the chief item of geological significance was a rock series largely composed of sillimanite garnet schist, as well as confirmatory evidence of other local findings that regional ice moved across the col from south-west towards north-east. Ascending northward from the col we reached the chief objective of the day's expedition, namely Point 2810 feet (aneroid), the highest summit in the district and the culminating point northward of the Northern Range. In clear calm weather, our delight only mitigated by mosquitoes, who had made the ascent with us, we surveyed the surrounding panorama. Westward the country fell away in extensive undulations to the complicated and broken coast-line of Ungava Bay, here fulfilling its true significance of "the bay beyond," *i.e.* beyond the mountains on which we stood. We thought we could discern a narrow line over the watery horizon of the bay, marking the high eastern coast-line of Akpatok Island, some 100 miles distant, and we wondered whether our friends of the Oxford Expedition could yet have reached its remote shores. Northward Cape Chidley and the Button Island appeared in a position which the existing map seemed to disallow, while nearer in the archipelago a bold headland marked the entrance to McLelan Strait ("Grenfell's Tickle"), and led the eye on to Mount Sir Donald, which rises on the south side of this tortuous channel of treacherous tide-rips. To the south-eastward, over a vast sea of mostly rounded summits, could be seen the jagged outline of the "Four Peaks" Group, rising as erosion remnants, or "monadnocks," above the uplifted Torngat peneplain. The crest-lines composing this general level, although accordant in greater degree, were clearly moulded into moutonnée forms, many indeed of which sank beneath that level, and the aerial photographs bring out in striking fashion the ruling disposition of steep lee sides to the east and gentler stoss, or impact, sides on the westward from whence came the continental ice-sheet. But differential valley and cwm erosion in the later stages had here, as elsewhere in the region, deeply dissected portions of the uplands, and formed valleys of cañon-like proportions. Whilst I was busy with observations on the summit of Point 2810 feet, some of the party resorted to the primitive though fascinating pastime of rolling precariously perched blocks and boulders into a smaller though profound example of one of these cañons on the north-west side of the summit. Nor could I resist the temptation to join in the fun, and the resulting din and dust in the abyss were sufficient to call forth the unanimous appellation of "the valley of ten thousand smokes"!

After about two crowded hours of sunshine on this summit we descended on its eastern side, and skirting some steep crags, made our way down snow-slopes and boulder-runs to a wild lake in the valley. Seemingly endless stretches of "Felsensee" eventually brought us on a north-easterly course to the coast

Southern section of the Northern Range, near the south end of Eclipse Harbour

near the mouth of the main fjord, and at an appointed place we were met by Madden with the motor boat. The *Ramah* had moved her anchorage to a small cove formerly used by Iselin's expedition on the east side and at the entrance of the main fjord, and a beautiful evening run over dark glassy water, marvellously reflecting the surrounding mountain forms, brought us thither at dusk. So ended our work in the extreme north, and on August 15 we sailed southward.

Mount Razorback

We had not cleared Cape Kakkiviak before encountering quite unexpectedly the hospital ship *Strathcona* with Sir Wilfred Grenfell aboard. The latter had searched for us in all the fjords from Nachvak northward, and was carrying for us a much needed supply of fuel oil as well as petrol, now no longer wanted, for the seaplanes. We sailed south together, and after a night's anchorage at our old base at Seaplane Cove, made for the vicinity of Mount Razorback. This mountain has been described as without a parallel on all the American coast, and its 3 to 4 miles of saw-toothed crest-line must have few rivals anywhere. It bounds Nachvak Fjord at its entrance on the north, and on its northern flank a smaller inlet, not shown on the chart, except for a slight re-entrant on the south side of Cape Whitehandkerchief, gave us an excellent anchorage, and access to perhaps its most spectacular side. Some weeks earlier Dr. Forbes had flown me over Mount Razorback, and a great impression had been left on my memory as to the ruggedness and the seeming inaccessibility of its pinnacled summit ridge. We were prepared therefore for a serious expedition when Morris and I started out early next morning to reach the summit and cross it to Nachvak Fjord, while the *Ramah* sailed round to the latter.

An ascent of about 1200 feet brought us to the snout of a small glacier, and at 2000 feet our route lay up steep rocks for 800 feet that unexpectedly gave out on a gap on the summit ridge. Climbing a tower to the westward we could see that in all probability the highest point of the long be-pinnacled ridge might lie farther east. A long and interesting climb, reminiscent strongly of the Cuilin of Skye, or even the Charmoz of Mont Blanc, brought us eventually to a summit which the aneroid indicated to be 3520 feet above sea-level. Razorback is given on the Admiralty Chart as 3000 feet, and now to our disappointment it was clear that an even higher peak than that on which we stood lay about half a mile farther off to the east along a most uncompromising arête. With a steep descent to accomplish, as well as the traverse of a quite unknown stretch of country, before we could pick up the new anchorage of the *Ramah*, it was essential not to prolong the climb to what is now known to be the culminating point of Razorback. This peak has been computed to be 3665 feet. A long descending scramble to an ice-slope, giving out on a typical "glacierette," brought us into a wild corrie running southward towards the coast of Nachvak. Like others in the region this small glacier did not exceed 700 yards in length, and it was evidently in a retreating and waning condition. Its almost siltless melt-water fed a series of blue-green tarns lying one below the other in the rocky moraine-spread valley. Our last labours that day consisted in finding a way over vast extents of "Felsen-

Looking south from Mt. Ikordlearsuk over Torngat peneplain; foreground frost-riven, formerly glaciated

Bishop's Mitre: west peak seen from the east peak; Brave Mountain in background

Mount Ikordlearsuk (in the foreground)

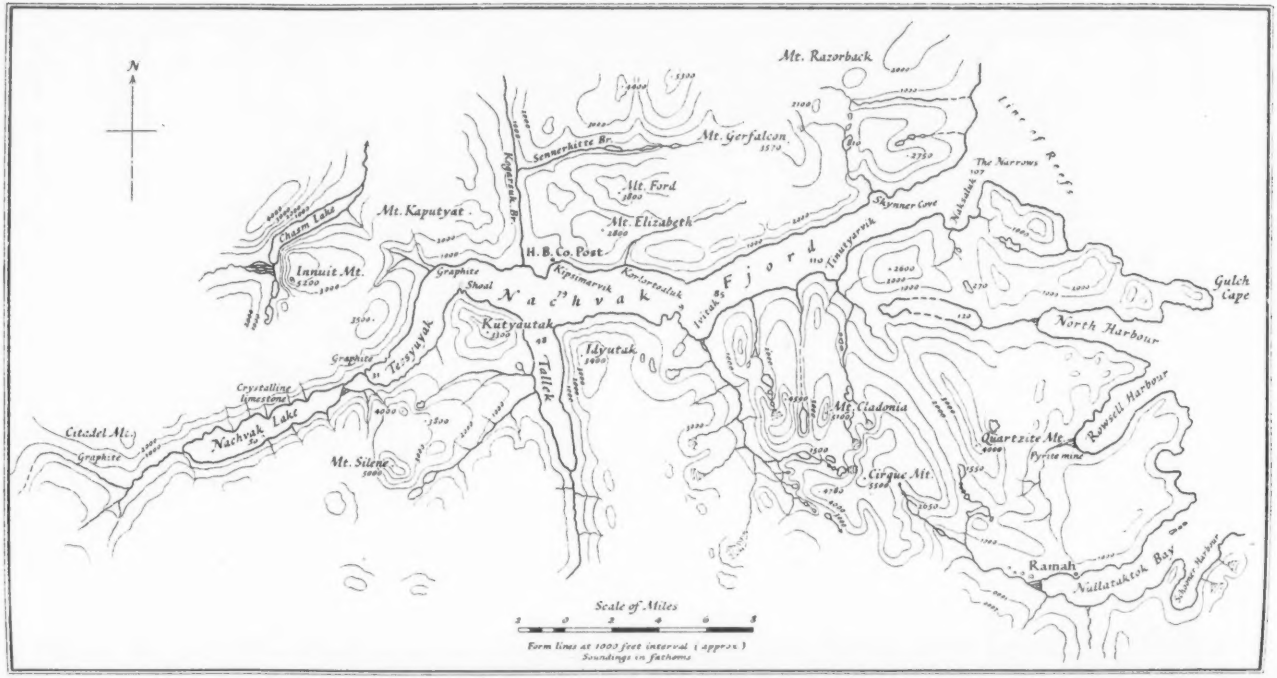
see," and through mountainous country quite unreconcilable with that shown on Coleman and Daly's maps, and in the gathering darkness over a further unmapped pass of close on 2000 feet, before we eventually reached at 11.40 that night the shores of Skynner's Cove and the awaiting *Ramah* and *Strathcona*.

Not the least interesting of the day's findings was that Mount Razorback consists of a rather rare type of intrusive rock, namely "charnockite," which gives prominence to this ridge amidst the more destructible gneisses into which it has been injected. This charnockite is of a coarse granitic nature and characterized, apart from the presence of the dark mineral hypersthene, by a blue opalescent quartz, which at places was segregated in pockets and veins, appearing strikingly like true opal. But many dykes of basic character and acid veins of pegmatite have invaded the charnockite. The eminence of Peak 2 of the range on which we had stood is due to the greater resistance to atmospheric weathering of the former basic rock; and it is to a great rhomboid mass of pegmatite plastered on the face of the headland that Cape Whitehandkerchief in the vicinity of Mount Razorback owes its name. There are reasons for believing that the intrusion of this great mass of charnockite may be connected with that of the eruption of the anorthosite series, which forms the bulk of the region underlying the Kiglapeit Mountains far to the southward: dykes of both anorthosite and hypersthene rocks, and of apparent contemporaneity, were found farther north at Kangalaksiorvik. That Razorback presents such a jagged outline in contrast with the more rounded, apparently glacially younger forms in the neighbourhood would seem to be due as much to its having existed longer than the surrounding hills as a frost-riven nunatak at the margin of the continental ice-sheet, as to the greater resistance its compactness of structure offered to the onset of that ice-sheet.

Nachvak

August 18 was spent in a sail down Nachvak Fjord in beautiful weather, and the fine character of the scenery and the wonderful colours and forms of the surrounding mountains made a great impression on the *Ramah's* company. Dr. Forbes was good enough to make the visit very largely on my account so that I might inspect certain features on the north side of the fjord giving evidence of the former maximum ice-level. Daly had reasoned from the polished slabs and the "streaming Felsenmeer" above them on the southern slopes of Mount Ford, that the ice-level could not have exceeded 2100 feet above sea-level, but Coleman considers even this too high. Moreover while the former authority believed that the continental ice-sheet made its way through the mountain valleys to the sea, the latter has maintained (p. 26) that the only glaciers draining to the Atlantic were local mountain ones. I was able to satisfy myself on Mount Ford of the existence of Daly's evidence, but I could not agree that 2100 feet represented the maximum ice-level of the district. Across the fjord to the south-east near Cirque Mountain could be seen a magnificent example of a U-shaped col, mapped by Coleman himself as 2590 feet above sea-level, and other similar features in the neighbourhood were all eloquent of a time when the ice-flood level at one period of its existence approximated closer to 3000 feet than 2000. And moreover the upper valley

Mount Ikordlearsuk (in the foreground)



Nachvak Fjord, Labrador (from Professor A. P. Coleman's geological map of 1921)

and river, draining through Nachvak Lake to the fjord, is a great glaciated through valley nowhere probably exceeding 1000 feet above sea-level, even where it merges into the low uplands on the western side of the Central Range, and this can only be explained by postulating drainage eastward from an ice-cap in the interior. But apart from this, as I have said before, it is dangerous in such a region to accept frost-riven material and Felsenmeer as criteria of emergence, either perpetual or of lengthy duration, above the ice.

At Nachvak our work in the North was virtually completed, a second short visit to the Kaumajet Mountains, as already recorded, alone remaining. Making brief anchorages only on our way south, and taking advantage of fair northern winds, we eventually put in at Corner Brook in the Bay of Islands in western Newfoundland, having consumed five days sailing only from Hopedale.

Summary of Geomorphology

Only the briefest summary can here be given of our geological and geomorphological findings in Northern Labrador.

The whole country is underlain by ancient metamorphic rocks, of which gneisses and granulites rich in biotite, garnet, and hornblende can be said to predominate. These would seem to be part of the Canadian Archaean Shield, and it is probable that all rocks present in the region are pre-Cambrian in age. The latter statement applies to such formations as the Ramah Series south of Nachvak Fjord, lying mostly at moderate angles unconformably upon the aforementioned gneisses. With the Ramah sedimentary series can be linked the volcanic and sedimentary series of the Kaumajet Mountains, which seem to be approximately equivalent in age to the former. The Ramah and Kaumajet formations may be regarded as Late Proterozoic and to correspond with the Animikean (Upper Huronian) and the Keweenawan rocks of the Canadian Shield.

Cutting the basement gneisses, but not the Ramah Series, are a great number of basic dykes, forming "dyke-swarms" in some areas. These are of doleritic or diabasic composition mostly, but some are ultrabasic—pyroxenite, anorthosite, etc. It seems that the latter, as well as the charockite of which Mount Razorback is composed, may belong to the period of eruption of, and be contemporaneous with, the great anorthosite-gabbro complex of the Kiglapeit Mountains farther south. Apart from pegmatites and local acid differentiates, granite intrusions that might have accompanied the original mountain-building movements are absent from the region. It is to this absence that the lack of mineral deposits of economic importance is no doubt due. Indeed, apart from the pyritous deposit in the younger Ramah Series at Rowsell Harbour earlier referred to, no sulphide mineralization was seen anywhere in the Torngat country.

The Kaumajet Mountains are a great pile of volcanic derivatives: basaltic lava and ashes, peridotite, etc., with much trachytic tuff at Bishop's Mitre, the whole cut by occasional basic dykes. Only a restricted sedimentary formation, consisting of about 40 feet of slates, was found at the base of the volcanic series, although Daly had reported quartzites, limestones, and sandstones, besides, from the island of Ogua'lik, unvisited by me, opposite these

Nachvak Fjord, Labrador (from Professor A. P. Coleman's geological map of 1921)

mountains. The vent (or vents) from which all the great mass of volcanic material was ejected is unknown.

The foliated rocks of the Torngat Mountains are all oriented between north and south and north-west and south-east, which is indicative of the old trend of folding of the region. It is merely the roots of the original folds that are now to be seen, and mostly vertical structures, while great dislocation and overthrust is inconspicuous in the field.

Whatever may have been the magnitude and extent of the ancient folded mountains they were deeply peneplained in post-Cambrian time. Later, at a date at present indeterminable,[1] the contemporary coastal region was uplifted to an elevation probably far in excess of the height of the present mountains.

An important physiographical discovery of the survey is the existence in the region of an "inconsequent" drainage, in that rivers flowing to the east cut through the Central Range of the Torngats, just as fjords transect the coastal ranges, and the present watershed of the country is considerably to the westward of the highest peaks of the Central Range. These may be considered to be "antecedent" rivers that have maintained their courses against the uplift of the region, but their rectangular pattern is clearly indicative of structural control. Until however the topographical map of the region is available no full analysis of the history of the drainage can be given.

The general geomorphological effects of glacial and post-glacial times have already been dealt with in some detail. As opposed to the view of Coleman and others, there is clear evidence that not merely did the Labradorean ice-sheet of the Pleistocene reach the Atlantic through the great transverse valleys of the Torngats, but that it also completely inundated the Torngat and Kaumajet Ranges. There is much superficially to suggest that an ice-sheet never entirely covered the country, and the jagged and broken character of the coastal groups have been pointed to as forms that escaped ice-planation. Rounded summits with a covering of rock debris have also been considered indicative of having been subjected to a longer period of atmospheric weathering than could be accounted for since the lapse of the Glacial Epoch alone. From observations elsewhere in the Arctic however the writer has found that the latter consideration depends very much on local circumstances. High terrain in proximity to the sea, with ample moisture-laden winds in a region of intense frost action, have been observed in the mountains of Spitsbergen to produce thick coverings of frost-riven stony soil, entirely since the recent disappearance of the local ice-sheets. Moreover the sharp jagged peaks of the coastal belt of these regions can be more plausibly explained, in the writer's opinion, by the same intense frost action that has operated upon them for a longer period since their emergence from ice covering than upon the higher still partly *névé*-covered tableland of the interior. But, apart from this, actual evidence of ice-polished surfaces was found at 4700 feet on a summit of the Central Range of the Torngats, nearly 3000 feet above what others have thought to be the maximum ice-level. And moutonnée surfaces were also found on one of the highest

[1] H. C. Cooke, in a recent paper, *Trans. Roy. Soc. Canada*, xxiii–v, sec. 4, 1929–31, has maintained that the uplift of the Labrador peninsula, with local warpings, took place in Pliocene times. But the Torngat region was probably elevated earlier.

Mount Razorback from the north-west

Nachvak Fjord from the south-west; Mount Razorback on the left

summits of the Kaumajet Mountains. Consequently Fernald's thesis [1] that these northern mountains formed nunataks on which conservative Cordilleran plants survived above the ice-sheet can no longer be maintained. Indeed, a striking feature was the lack of the very plants suggested by him to occur on mountain-tops in the region: any so-called endemic plants appear to be more characteristic of particular distributions of suitable soil than indicators of a lengthy period of colonization.

It is known from the findings of A. P. Low in the interior, that during the Pleistocene Glacial Epoch the centre of dispersion of the ice was in the central parts of Labrador, at about lat. 55° in its later stages. In central North America at least four separate ice-advances from the Labradorean and other centres can be demonstrated, but so far no definite evidence of multiple-glaciation has been found in Northern Labrador. But if there were more than one ice-advance, the visible effects in the region would seem to be explicable by one ice inundation during a single epoch, and as explained earlier, by the superposition of a cycle of mountain glaciation upon an earlier continental one. As far as our knowledge of the region at present goes, we may picture it as having for a long period formed a rocky archipelago in the glacial *mer-de-glace*, and being only completely submerged during maximum glacierization. The moulding of the valleys and the general dissection of the region have been partly due to river and stream erosion before the onset of the Ice Age, and glaciers and *névé* have later enhanced and deepened these features, as well as sculptured the high corries and cirques, in which small relict "glacierettes" are often still to be found.

Reference must be made to the remarkable series of raised beaches at varying levels which Daly in particular showed (pp. 254 *et seq.*) to be in evidence all along the coast from southern Labrador to Nachvak. He showed that the highest elevated shore-line is by no means constant, but tends to be more depressed in Northern Labrador than farther south. His northernmost observation at Nachvak gave the highest shore-line as 250 feet, while farther north at Seaplane Cove I found this to be about 200 feet, which compares favourable with Coleman's 225 feet in that neighbourhood. Northward again the evidence was obscure, but at Ryan's Bay at 75 feet above sea-level was a marine-cut morainic shelf, and at Ikordlearsuk, our farthest north, there was no positive evidence of rise of the land. All observations therefore conform to the view that there has been differential elevation of the coast, giving an apparent northerly tilt to the region. As in Scandinavia, and other formerly glaciated countries, such widespread crustal movement has been shown to be proportional to the ice-load once held by the country, depression of the latter having been followed by progressive though somewhat variable uplift. Another factor in the situation is the release of melt-water from the vanishing ice-mass, which brings about a general (eustatic) rise of sea-level, thus diminishing the apparent rise of land as shown by sea-level. There are several additional factors besides; but such an elevation as 250 feet for the highest shore-line at Nachvak can be considered as commensurable with the former great ice-loading of the Torngat region, a condition with which other lines of evidence concur.

[1] M. L. Fernald, *op. supra cit.*

Nachvak Fjord from the south-west; Mount Razorback on the left

But if there is evidence of elevation, there is at the same time clear evidence of earlier depression of the region. The irregular shore profile, the many branching bays, and drowned valleys, the numerous islands and peninsulas, all point to a coast-line of submergence. Many of the aerial photographs emphasize these features, and bring out additional evidence of a "youthful" stage in the coastal development. Some of these same features however are in striking contrast with instances of "maturity" elsewhere, as evidenced by the bold cliffs near the entrance to Nachvak Fjord, which appear to drop into very deep water. Coleman (p. 15) has suggested faulting as a possible cause of the latter peculiarity, but until more is known of the off-shore submarine topography, as the result of the present Admiralty hydrographical survey, this can scarcely be conclusive.

The western side of the peninsula along the Ungava shore has too all the characteristics of a "drowned" coast-line. It would seem probable that there may have been, during pre-glacial and early glacial times (or inter-glacial, if such ever obtained in these parts), a prolonged still-stand of the sea at about the present level. Otherwise it is difficult to reconcile such features of sustained submergence as bold cliffed headlands and broad promontories, rising in some cases nearly 1000 feet above sea-level, with the evidence of such recent emergence of the land as the widespread raised beaches. The latter may have been formed in a relatively transient period when the land-ice from the interior had shrunk back from the coast-line and exposed it to the processes of deposition that preceded its re-elevation. The reports of fishermen in the south, who claim that their moorings have in places emerged from the sea within living memory, bespeak continuing re-elevation, but nearer the hinge-line, which is presumably in the vicinity of Hudson's Straits, as well as in the absence of human settlements and local observation, it is unknown whether uplift is still proceeding: if it is, it is probably only slight.

When the topographical map of the region, which is being prepared at the American Geographical Society mostly on a scale of 1 : 100,000, from the results of the aerial survey, is completed, it is hoped that the geomorphological history of the Torngat country will be able to be worked up in greater detail: at present certain aspects of that history which is outlined above must in the absence of a map be considered as provisional only.

DISCUSSION

The PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: I do not know—perhaps few do—which European first visited Labrador. Whether Lief Eriksson actually landed there is not quite certain; certainly if he did not land he went very close to Labrador. Whether he was encouraged to go there by a former voyager of fifteen years before, or whether he saw Labrador as he came north from his voyage to Greenland on his way back to Finland is not quite certain. What is certain is that he reported Labrador as a very poor country, and as he was coming from Finland and going to the north that is nothing to be surprised at.

The first Bishop of Finland and Greenland may not have had much to do, but about one hundred years ago it was reported that remains of stone engravings were found with Christian marks showing that they were put up in the year 1135. Then came rumours of a great city, probably confounded with Newfoundland, and many seamen journeyed to those parts. But the real discoverer of Labrador

was John Cabot. After he had been there many followed. You may have read a book by Sir Wilfred Grenfell, with a preface by Mr. Wallace, in which he says that Labrador itself has very little history. At one time it was a hunting-ground of slaves; at another time the Brest or Breton fishermen gave some of the names to harbours in Labrador, and it was certainly visited by other people.

There is a mental reaction to certain names. If you hear mention of Agra, I suppose you see the Taj Mahal, and if you mention Istanbul, you think of San Sofia. There is no doubt when one speaks of Labrador the mental reaction is at once Sir Wilfred Grenfell. Mr. Odell, who is to lecture to us to-night, went on a trip, not with Sir Wilfred, but with Dr. Forbes, of Harvard University. Mr. Odell is well known as a geologist, geographer, and mountaineer. He has travelled widely, observed well and with appreciation, and recorded with great discretion. I invite him to give us the results of that travel and that observation.

Mr. N. E. Odell then read the paper printed above.

The PRESIDENT: Mr. Odell has given us an account of one aspect of Labrador. I will attempt to give another when I say something of Wilfred Grenfell. If there is anything to be made out of that country it will be due to him. I have had much conversation and a certain amount of correspondence with him, and though I dare say we may not all be able to share all his enthusiasm about Labrador, there is no doubt that he has turned a very barren land into one which is a habitation for a certain number of men and women. Indeed Sir Wilfred Grenfell, with the magnificent enthusiasm he has, thinks Labrador is going to be the place where all the rich Americans and others will go on northern cruises in the same sort of way as some of us now go to Norway.

Mr. Odell has given a most interesting account of a place which is little known, and I speak in all seriousness when I say that when the population is doubled, when the coast is properly surveyed and it is a habitable place, the credit for that will be due to men like Mr. Odell who go as pioneers and search out these strange places. I beg, therefore, Mr. Odell, that you will accept from this audience and the Society our very cordial thanks for your work and for the way in which you have given us an account of it this evening.

THE WOOD'S HOLE OCEANOGRAPHIC INSTITUTION: Sonic Soundings, and an account of a Winter Cruise to the Somers Islands[1]

JOHN COLMAN

THE Wood's Hole Oceanographic Institution is an independent organization with its laboratory at Wood's Hole, Massachusetts, where there are also the Marine Biological Laboratory and a branch of the United States Bureau of Fisheries. The first of these has an excellent biological and oceanographical library, and by friendly co-operation this is made freely available to workers in both of the other laboratories. The Oceanographic Institution is the youngest member of the group, for it was founded in 1930 and started work in 1931 under the direction of Professor H. B. Bigelow, the finances coming from the Rockefeller Foundation. The headquarters of the Institution are not the laboratory buildings, but the research vessel *Atlantis*, built by Messrs. Burmeister and Wain at Copenhagen and taken over in June 1931.

The *Atlantis* is a steel, auxiliary, Bermudian-rigged ketch, 142 feet overall, with a maximum draught of 17 feet and a displacement of 460 tons. Her masts are wooden and hollow, the mainmast rising 130 feet from the deck and the mizzenmast about 100 feet. She is double ended, with no bowsprit, and she carries a jib, fore-staysail, mainsail, and mizzen, giving a total of 7200 square feet of canvas. She will sail well within five points of the wind, which is not bad for a vessel of her size and sail area, and built primarily for work; she is stiff enough, steers easily, and her 280-h.p. Diesel engine will push her along at 8 knots in smooth water.

Just abaft the engine-room is the main winch, on whose drum are wound 30,000 feet of $\frac{1}{2}$-inch diameter wire, which has a breaking strain of 12 tons and is still as good as new. This is led from a short boom by the starboard main rigging, and has been used so far for heavy plankton and trawling work, dredging not having yet been attempted. On the starboard side of the mizzenmast is the hydrographic winch, which is used for all light gear, such as water-sampling bottles, bottom samplers, small plankton nets, and so on, and also for hoisting the mainsail and the mizzen. On the deck on the port side, amidships, there is a nest of three Nova Scotia dories, so that all work has to be done on the starboard side, where the deck is uninterrupted between the main and mizzen rigging.

After the vessel was taken over in Copenhagen, she started on a six weeks' crossing of the Atlantic from Plymouth to Wood's Hole, Massachusetts. After proceeding to a point to the westward of Ireland, the *Atlantis* sailed due south till she made the Azores, and then worked west and north to her destination. During the whole of this voyage stations were worked for chemical and physical observations on the sea water, samples being taken at many depths down to 2000, and in some cases 3000, metres. These observations can be added to those made by the *Michael Sars*, the *Dana*, and other research ships

[1] Contribution No. 20 from the Wood's Hole Oceanographic Institution.

working in recent years in the North Atlantic, but owing to the lapse of time between the work of different expeditions they must still be treated empirically. On this cruise the vertical distribution of plankton in relation to light intensity was also studied, and this constitutes what is perhaps the most accurate field-work on pelagic macro-plankton yet attempted.

Since reaching America, the *Atlantis* has been based at Wood's Hole, and has made several short trips to the Gulf of Maine. In these excursions the usual water-sample and plankton investigations have been carried out, but to them has been added work on bottom-samples and their associated bacteria which may be of great importance in connection with the nitrogen cycle of the ocean and the disposal of waste and dead matter in the sea. Perhaps the happiest side of this work lies in its being undertaken by geologists, palaeontologists, and soil-bacteriologists, who are bringing in ideas and methods which might otherwise never reach the heads of people with only marine experience.

In the spring of 1932 the *Atlantis* made a prolonged cruise through the central part of the North Atlantic, including a section running due south from a point on the thirty-fifth parallel to the mouth of the Amazon on the Equator. During this voyage she was out of sight of land for seven weeks without unduly straining her fuel, food, or water supplies. In the second quarter of 1933 she has spent three months in the Caribbean Sea. Work has also been done in collaboration with the United States Bureau of Fisheries, but the central part of the first two-years' programme has been an intensive study of the water between the United States and Bermuda. This is being carried out in a series of eight quarterly cruises to that island, of which the fifth, completed in December 1932, was fairly representative of the work of the Institution as a whole, and is described later.

From the first it had been intended to equip the *Atlantis* with sonic sounding apparatus, but for financial reasons it was not until the latter part of 1932 that a "fathometer" was installed. This instrument has been fully described in the *Hydrographic Review*,[1] and the following account is based on that description. It is of the sonic, as opposed to the super-sonic, type, and the depth indications are obtained from one or other of two concentric dials; one gives depths down to 125 fathoms, the other from this depth down to about 3000 fathoms, or even more under favourable conditions. In the shoal range the sound producer is a Type 399 oscillator mounted inside the ship either in contact with the hull or suspended in a water-tank. The sound produced by this oscillator is powerful but of very short duration, resembling a heavy hammer blow. About twenty-four signals are produced per minute. The echo, after being received by two hydrophones, is converted into an electrical impulse which flashes a rotating neon tube, thereby causing a visual indication of depth to appear on the dial.

In the deep range the sound producer is a Type 324 oscillator mounted in a heavy casting which is riveted to the outside of the hull. This oscillator produces a clear musical note of about one-tenth of a second duration. Normally about twenty-four signals are produced per minute. In receiving the sound echoes from the sea bottom a tuned hydrophone is used. It is particularly sensitive to the musical note emitted by the oscillator. While sound-

[1] "Echo Sounding, 10, 2. Fathometer of the Submarine Signal Corporation, Universal Type 432," *Hydrographic Rev.*, 8, 2 pp. 176–183.

ings in the deep range are being made, a narrow beam of white light from an incandescent lamp moves steadily round a calibrated dial. The operator

Fig. 1. Area off the East Coast of North America in which the sonic soundings were taken

obtains depth measurements by observing the position of the beam of white light at the instant the echo signal is heard in the telephone receivers.

Echo sounding has now become a commonplace aid to navigation when on

soundings, but it is also an almost essential part of the equipment of any vessel undertaking deep-sea oceanography, unless one is prepared to run the risk of losing apparatus through its striking an uncharted submarine mountain. In the shallow water over the Continental Shelf this is not likely, except for the possibility of wrecks on the bottom, such as one we encountered off New York, mentioned below, since it is easy to take a cast with the lead, and besides there are now very few coastal regions that are not tolerably well charted, whereas in the deeper parts of the oceans, especially away from steamer tracks, soundings may be several hundred miles apart. In shallow water also, where only a few sampling bottles are on the wire and only a limited amount of wire is over the side, the lead makes up most of the total weight. If it should strike the bottom unexpectedly, so much strain will be taken off that the winch will stop, or at any rate suddenly slow down, and give warning to those on deck. It may be mentioned that it is common practice to lower the lead into the water before attaching any bottles to the wire; this prevents the lead from swinging to the roll of the ship and so hitting the hull, and it also means that there are some 10 feet of wire below the lowest bottle, which ensures that the gear will not immediately hit the same obstruction as the lead.

In deep water however this precaution is useless, since for the sake of strength and safety fairly heavy steel wire must be employed, and several thousand feet of it weigh considerably more than the lead at the end; when to this are added the combined weights of ten or more Nansen bottles, it will be seen that should the lead strike the bottom it will make no great difference to the total strain on the winch, and that the weight of the wire and bottles will make it go on paying out with no hint on deck that anything is amiss.

This is not mere theorising, and uncharted submarine mountains do exist, even in such relatively well-explored waters as those of the North Atlantic. On 29 February 1932 the *Atlantis* was making a hydrographic station in 30° 20′ N., 51° 45′ W. This was before the installation of the fathometer, and no sounding was taken; it would have occupied several valuable hours, and anyway there were two soundings on the chart within 100 miles of the position of 2875 and 2600 fathoms, which made it appear safe enough to let down bottles at any rate to 1500 fathoms. A bottle which had reached 1713 metres or 940 fathoms came up in good order, but the deepest bottle, from 2570 metres or 1400 fathoms, was smashed, and the lead was deeply scored and had evidently been dragged for some distance over a rocky bottom. In other words, the depth was between 940 and 1400 fathoms, and was at least a mile shallower than was indicated by the chart (British Admiralty Chart 2059, North Atlantic), in spite of the fact that the printed soundings were relatively frequent.

Since the installation of the fathometer it has become part of the ship's routine to take a sounding every hour when in deep water. This unfortunately necessitates the stopping of the main engine and generator, should these be running, on account of the size of the hull. In a big ship the hydrophone which receives the echo from the bottom can be placed hundreds of feet away from the engines, the principal source of noise; in a vessel of the size of the *Atlantis* this is of course impossible, and at depths of over 300 fathoms any engine noise will drown out the sound of the echo. In still smaller ships, the noises made by

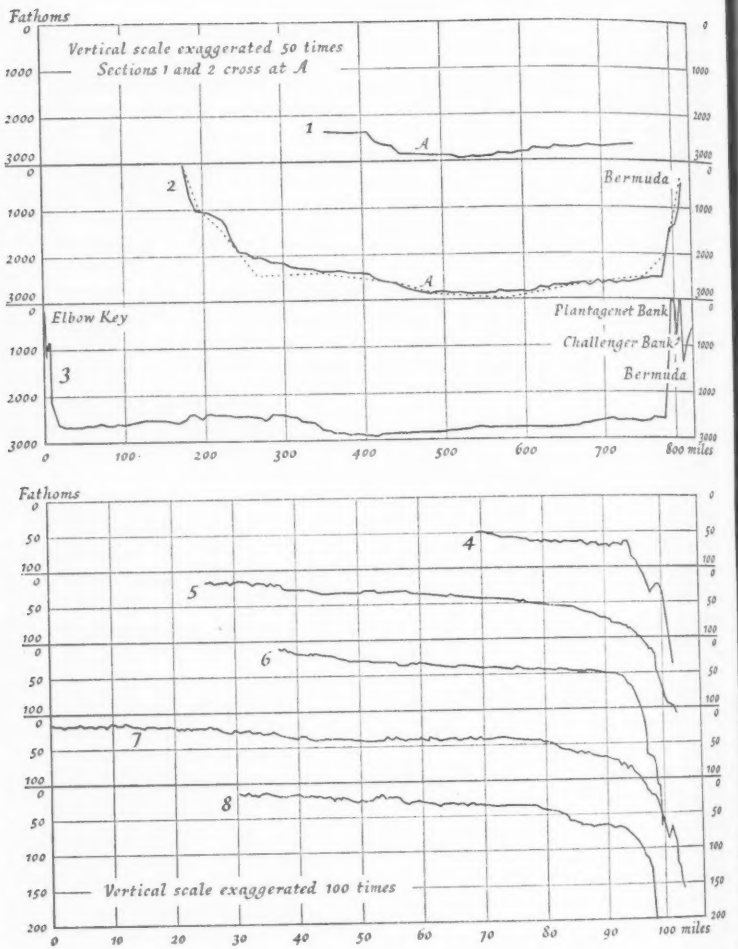


Fig. 2. Sections of sonic soundings : positions shown on Fig. 1

the hull itself become more obvious in the head-phones, so that it is probably little use to install this type of sonic sounding apparatus for deep-water work in vessels of less than 300 tons or thereabouts.

These soundings have resulted in sections 2 and 3 (Fig. 2), one from off Cape Hatteras to Bermuda, and the other from Bermuda across Challenger and Plantagenet Banks to Elbow Key in the Bahamas. These both emphasize the much more gradual slope off a continent than off an oceanic island (the Bahamas as a group being considered as the latter, since they are separated from the mainland by deeper water than that over a continental shelf). They also show what looks like a secondary shelf about 300 miles from the continent, where the depth alters in about 50 miles from 2400 or 2500 fathoms to 2900 fathoms. This outer shelf is quite steep in places, as shown by section 1, which was made on the return trip from Bermuda, but which could not be accurately drawn in as far as the coast, as for several days there were neither sun nor stars with which to fix our position.

The broken line in section 2 is derived from the soundings printed in U.S. Hydrographic Office Chart No. 1411, Halifax to Haiti, and agrees fairly well with the section made with sonic soundings except in the entire absence of detail, and in the case of one sounding about 80 miles off the Shelf. Here the fathometer gave 2050 fathoms, but the chart 2450 fathoms, a difference of nearly half a mile. This position is in the path of the Gulf Stream, and it seems probable that the sounding in question was taken by the lead, in which case the relatively rapid surface drift would have taken the ship away from a position vertically above the lead; this factor could easily introduce errors of this magnitude. It would be a welcome innovation if, in future editions of oceanic charts, echo soundings of more than 500 fathoms were to be distinguished typographically from soundings made with the lead. The latter are rarely accurate, and may be very wrong, and can only be taken as indications of depth.

In Fig. 2 are drawn out five sounding sections across the brow of the Shelf, so arranged on the figure that the 100-fathom lines are vertically above one another. In three of them, Nos. 5, 7, and 8, the pitch of the slope increases appreciably at about 40 or 50 fathoms, but does not become really steep until 70 or 80 fathoms, when it plunges into the abyssal depths; in Nos. 7 and 8 this double break is so marked that the sections appear concave. Sections 4 and 6 resemble each other in having a very sharp edge to the shelf, but although they are quite close together, only 40 miles apart in fact, section 5, which is between them, shows a very different profile, with no sharp edge. It would seem that here is a geological problem, concerned with the nature of the rock underlying the bottom. The sea-floor appears to be more uneven in the more southerly sections, but it must be kept in mind that the vertical scale is 100 times the horizontal, so that the corrugations are actually very slight.

Finally, there are three sections across the Hudson River Mud-Gorge, shown in Fig. 2 on a vertical-horizontal scale of 10 to 1. Similar deep submarine valleys are quite common, and have been recently discussed in the *Geographical Review*.[1] They are very definite in shape and, for submarine slopes, of astonishing steepness. The form is usually that of a V, the rims are very sharp, and the

[1] Francis P. Shephard, "Submarine Valleys," *Geogr. Rev.*, 23, 1, January 1933.

actual dimensions are comparable with those of the biggest terrestrial valleys. For instance, the Grand Canyon of the Colorado River, in Arizona, among the most spectacular chasms in existence, is about 1 mile deep, and 13 miles wide at the narrowest part; the Hudson Gorge, at section 11, is about 400 fathoms, or a little less than half a land mile, deep below the brim, and 5 sea miles wide. This is deeper in proportion than the Grand Canyon, in spite of the sediment that one would expect to be accumulating in the Mud-Gorge. These valleys extend seawards as clefts in the Continental Slope to depths of more than 1000 fathoms; good examples are those off the Congo, off the Ganges, and in Monterey Bay, California, where there is at present no sizeable river. The whole question of their origin and maintenance is a geographical and geological problem of the greatest interest.

On the cruise during which most of these soundings were made, we left Groton, Connecticut, on the Thames River, at 7.30 a.m. on 27 November 1932, and after rounding Montauk Point, sailed south by west. It was blowing a force 7 breeze from north by west and was very cold, with 20° of frost. The sea-water however was at 40° F., and the difference in temperature caused the formation of flecks of mist on the surface of the water; they looked just like balls of cotton wool rolling along at 20 miles an hour. They disappeared about 9 o'clock, when the sun was properly up. Soon the wind veered till we were running dead before it, and for more than thirty hours we averaged 8 knots under the main trisail only; the headsails were blanketed and of no use, and the mizzen could not be hoisted as it made the ship gripe too heavily. This fine sail was marred only by our rolling steadily 20° to windward and 25° to leeward all the way to Cape Hatteras. On the way we crossed the Hudson Mud-Gorge, making section 11; the soundings ran from 82 fathoms to 482 fathoms and back to 130 fathoms, all in 5 miles. The gorge has been used for centuries by vessels making New York on the lead in foggy weather.

It had been our intention to start a line of hydrographic stations from the shallow water at the mouth of Chesapeake Bay, out to the deep sea and on to Bermuda, but when we got to the Continental Shelf to the northward of Cape Hatteras it was still blowing far too hard to justify an approach to a lee shore, or to let us do any work, so we hove to for the night. The following day the wind had eased to force 5, and we sailed for the Shelf; although we were reaching under the somewhat reduced rig of jib, main trisail and mizzen (the staysail having been punched full of holes by the jib-sheet blocks), we averaged 10·2 knots for eight hours, a grand piece of sailing. After working our first station in 80 fathoms, we laid a course for Bermuda, and at last everything went smoothly. Stations were at first 15 miles apart, until we were across the Gulf Stream, then spaced out to 20, then to 30, and finally to 60 miles in the very constant and uniform waters between the Stream and Bermuda. At all stations, except those on the Shelf, samples were taken at sixteen depths down to 1200 metres, and sometimes deeper still, for temperature, salinity, and for phosphate content; some samples were also collected for nitrate and for diatoms.

The apparatus used was the Nansen bottle, which still more than holds its own as the best collector of water samples. It is one of the very few pieces of marine gear which merit the title of instruments of precision, but in spite of its great accuracy it will stand a surprising amount of rough treatment. The

thermometers (two per bottle) are of the reversing type, the mercury thread being broken before the bottle is brought to the surface, and they read accurately to 1/100° C. The bulb of one thermometer is surrounded by an outer glass case containing air, which prevents the pressure of the water affecting it, but the bulb of the other thermometer is in direct contact with the water, and will read about 1° C. too high for each 100 metres of depth. Comparison of the two readings will, after a simple calculation, give the precise depth from which the sample has been taken. This is an essential procedure, since except in the very rare combination of a flat calm and no current there is always a certain amount of drift going on, with a consequent departure of the wire from the vertical; in shallow-water work this can be allowed for after observing the angle between the wire and the vertical or horizontal, but in deeper sampling there is no certainty or even likelihood that the wire follows a regular path through the water to the lowest bottle, so that the use of unprotected thermometers is the only practical and reliable method for ascertaining the depths to which the bottles have actually been sunk.

On the four previous Bermuda trips, the hydrography had given almost identical results, so that it was beginning to be thought that this part of the sea was becoming fairly well known. The isotherms, which are crowded together over the Continental Shelf (where the bottom waters, though shallow, are always rather cold), drop precipitously at the north-western margin of the Gulf Stream, and then remain deep and widely spaced through the central part of the North Atlantic south-east of the Stream. In other words, the Stream is not so much a sort of river flowing over the surface of the ocean, an idea put forward in not a few geography books, as a vertical wall of considerable depth, having on its left hand cold, coastal water, but on its right hand warm, oceanic water much more like its own in composition. On this fifth trip however the isotherms all rose again on the south-eastern side of the Stream before returning to the levels which they maintain with little variation to beyond Bermuda. This, in conjunction with other data, is interpreted as an indication of a strong movement of water parallel but opposite to the Gulf Stream, perhaps part of a big vortex. All depths down to 2000 metres were affected, including the surface, as indeed we found out at the time when we were 50 miles beyond the Stream, for the *Atlantis* was set for a while to the southward of her dead-reckoning position.

From here we rolled on to Bermuda in beautiful weather, but with a big northerly swell and not enough wind to fill the sails. It had been our plan to stop only two days at the island, to get rested, but as our next job needed a calm sea and a light breeze, it was not surprising that we were kept for five days in St. George's Harbour until a very fresh north-easterly breeze died down. We then left Bermuda and sailed south for a day, and for two days had just the right conditions, except for the eternal and inconvenient swell. This calm-weather work was in connection with the retarding effect of the sea's surface on the wind, or, alternatively, with the propelling effect of the wind on the surface layers of the sea, and was bound up with the theoretical path, known as the Ekman Spiral, of a fluid mass moving over the surface of a rotating sphere.

On a previous trip the effect of the sea on the wind had been studied by releasing pilot balloons and plotting their paths through the air by taking

azimuth readings and measuring their height trigonometrically at given intervals of time. This proved too difficult from the deck of a small and not unlively ship to give much beyond qualitative results; the method is however being persevered with. The experiment on our trip concerned the other aspect of the problem, namely the effect of the wind on the sea, and it consisted in plotting the paths of glass balls ascending through the water at known rates from known depths, the balls being such as are used by fishermen as floats for their drift nets. Each ball was attached to a metal cone which kept its ascension rate down to about a foot a second, and they could be attached in a series down the wire and released by a messenger in much the same way as a series of Nansen bottles.

Let us suppose that the deepest ball will be released at 50 fathoms, with others on the wire between that depth and the surface. Then, if the ship and all the water down to that depth are stationary, or drifting in the same direction and at the same speed, the released balls will all rise apparently vertically, and come to the surface together close to the wire. If there is any differential drift, the balls will come up away from the ship at varying distances and directions, which can be measured by means of range-finder and azimuth readings. In practice it was found difficult to use a range-finder at all accurately when the balls were being frequently hidden by swells; the mizzen rigging or the wheel-house kept on getting into the line of vision of the man taking compass bearings, and here again only qualitative results could be obtained. An additional complication must be the turbulence caused by a rolling vessel drawing 17 feet; this turbulence could be plainly felt while swimming under water 30 feet from the ship. I believe, though, that this work could be done, with interesting and perhaps important results, by lowering and releasing the balls from a large raft, fitted with a 10-foot tower from which to take compass bearings and range-finder readings.

Having done what we could with the balls, we now set a course for the mouth of Delaware Bay, and every night took tows for plankton with two tow-nets each 6 feet across at the mouth. The main objective was the collection of eel-larvae for the late Professor Schmidt, of Copenhagen, who worked on these larvae from all over the world for a matter of thirty years, but we also experimented with a new net in an attempt to make collections of really deep plankton which should be uncontaminated by the richer material from the upper layers. For this purpose we tried out a net which theoretically could be sent down closed to the required depth, opened with a 5-lb. messenger, towed for a given length of time, and then closed again with a 20-lb. messenger, before being brought to the surface. A small net of such design has been used very successfully, but since the plankton of deep off-shore water is exceedingly scarce, we had to use much bigger and more cumbersome gear. It consisted of the usual type of conical net, and a special frame which was 8 feet wide at the mouth and weighed upwards of 200 lb. It was attached to the release mechanism, which was of heavy brass construction, by some four or five lengths of wire, varying from 10 to 40 feet. In designing it all on paper it was simple to draw the wire nice and straight and make it look easy to work, but in practice there is nothing quite so perverse as flexible steel wire, and usually one or two of the bridles threw a half-hitch round some part of the net or frame

and prevented it from working as it should. Moreover we were working at night, since we combined these deep tows with those for eel-larvae; it is no use fishing for the latter by daylight, as apparently they can then see the net coming and swim out of its way.

There was no fault to be found with the apparatus theoretically, and we struggled with it on several successive nights, but finally, after the gear had gone over the side looking really unentangled for the first time, it came up with the net torn completely away from the canvas band connecting it with the frame; this band, which had been bent to the frame with some thirty turns of heavy serving wire, was left attached by two turns only, and the frame itself was buckled, though made of galvanised iron half an inch thick and $1\frac{1}{2}$ inches wide! Either it was not strong enough to withstand the sudden shock of the net opening and filling with water, or else we had caught, and lost, a monstrous fish. All hands were profoundly grateful when this piece of gear was finished with; it was certainly too big and clumsy to be used on a vessel with the deck arrangements of the *Atlantis*, some sort of outboard derrick being essential.

Our arrival at the Continental Shelf off the Virginia Capes neatly coincided with that of a whole gale from the north-east. The barometer, which had been rather high, dropped almost an inch in four hours, and the wind blew hard for twelve, after first ruining the jib. Then it eased for half an hour, but came in at storm force from the north-west while the glass busily climbed back again; at no point had it been below 29·3 inches, and the whole affair was over in twenty-four hours. It was of short duration compared with a typical winter gale on the European side of the North Atlantic, but it left quite as disturbed a sea. Fortunately however our programme now took us in towards the land where we were fairly well protected. We made three more hydrographic sections across the Shelf in very fair comfort, though to be sure it was cold sailing close-hauled up the New Jersey coast; it was a luxury to have no swell.

The first of these sections was from the edge of the Shelf into the mouth of Delaware Bay, the second out from near the Ambrose Lightship off New York, and the last one in from south of No Man's Land until we made Gay Head Light as our landfall. On these runs the Nansen bottles again worked perfectly, as is their custom, and indeed on the whole the cruise, during which we collected more than four hundred water samples, not a single bottle failed to do its work, except on three occasions which were due to our own negligence, and when it was a simple matter to repeat operations. While on the shallow waters of the Shelf we were also taking sonic soundings every three minutes, partly out of curiosity to see if the bottom were really as smooth as the soundings on the chart led one to expect, and also to get detailed profiles of the brow of the Continental Slope. The fathometer helped us most materially in another direction however when we arrived at the position of one of our stations, at 39° 49′ N. by 72° 54′ W. For some time the echo soundings had been agreeing with those on the chart at 40 or 41 fathoms, but as we hove to we suddenly got only 32 fathoms. We checked and confirmed this figure with the lead, and for a while got various readings from 32 to 41 fathoms before drifting clear; it was presumably a wreck, and a big one too, to judge by the difference between the extreme readings. A single cast with the lead, if it had agreed with the chart,

would have given us confidence to let down our bottles to within 2 or 3 fathoms of the bottom, and this might well have tangled them up in the wreck or whatever the obstruction was.

On the last section in towards Gay Head our latitude was somewhat uncertain owing to our not having had a good afternoon sight, and the captain wanted to know exactly when we crossed the 50-fathom line, which hereabouts runs almost due east and west. With the fathometer this was simplicity itself, while the use of the lead would have entailed the fuss and bother of rounding to every so often in the fresh breeze that was then blowing. Finally, we arrived at New Bedford for Customs and Quarantine early on the morning of December 23, and reached Wood's Hole late the same evening.

KANO IN 1933

C. R. NIVEN

KANO, though at one time politically unimportant, has been since the sixteenth century the best-known commercial centre of the Western Sudan, the departure point of many caravan routes: now it is the heart of one of the densest populations in Africa; the great exporter of leather and ground-nuts; the early terminus of a long railway; and one of the progressive units in the development of native administration.

For some four centuries Kano, with the other states of the Western Sudan, had faced northwards across the desert, deriving its religion, culture, and prosperity from this tenuous contact with the Mediterranean; but the coming of the British administration and building of the railway have changed this orientation; now it looks across the sea to the outer world of modern western culture, not unaffected by a native population to the south of a different civilization and with an outlook imbued with European ideas. Its administrative reactions are therefore of the greatest interest.

The city of Kano lies almost in the centre of the Emirate of that name, which covers 12,212 square miles of mostly sandy fertile plain with slight undulations and occasional large rivers; of these the Hadejia River whose sources are to the south of the Emirate and which reaches Lake Chad as the Yobe is one of the most important. In the south and east there are some hills rising to the Plateau, but for a considerable distance from Kano in any direction the plain is unbroken save for inselbergs. The "North Mail" of the Nigerian Railway conveys the traveller in comfort from the mail steamer at Lagos to Kano, doing the 760 miles in forty-one hours—a journey of many weeks in the old days; at Zaria, the next important native town 100 miles to the south, the railway has climbed to a height of over 2000 feet above the sea from the 400-foot level of the Niger crossing at Jebba; at Kano it has run down to about 1500 feet above the sea.

The point which strikes the traveller nearing Kano from any direction is the obvious density of population and the manner in which the country for some 30 miles round it is closely farmed. Apart from the broad cattle tracks

and certain grazing areas and swamps in that radius, most of the ground is under almost continuous cultivation and has to be carefully tilled and manured, or it would be quickly exhausted; here the nitrogenous products of the ground-nut crop are of great value in maintaining the soil. On the whole the Northern Provinces of Nigeria are sparsely populated, and almost everywhere there is bush available for new farms when the old are worn out; but the population of even the outlying districts of Kano Emirate is high in comparison with elsewhere. The population at the last census of the Emirate was nearly two millions of natives, mostly Hausa or Fulani; of these some 320,000 live in the home districts within 15 miles of the city; within 30 miles there are over a million people.

The Kano products are the usual guinea corn, millet and ground-nuts for the most part, with many smaller crops such as cassava, onion, rice, etc. The country is mostly open, and though there are great trees to be found in the villages, and though in some places the locust bean is fairly common—and always beautiful—yet those used to the heavily timbered areas of the south or even to the ordinary "orchard bush" are impressed at first by the bareness of the scene. In time however there comes a curious pleasure in the broad level views. This absence of timber, due to the concentrated farming population, has the economic effect of making fuel and building woods difficult to obtain.

The Emir, who is one of the ruling family given authority by Muhammad Bello, second Sultan of Sokoto, early in the last century, is the head of the Native Administration, and all its functions are discharged in his name. He is advised by a council, which meets twice every working day, composed of the senior native officials—the Waziri (dealing with justice and law), the Madaiki (once commander-in-chief, now in control of district affairs), the Galadima (the Emir's brother and head of the City Administration), and the Ma'aji (the Native Treasurer). Each of these directs the affairs of his department and takes responsibility in most things, though the Emir is consulted on the more important.

This council, strengthened by additional legal members, is also a judicial council, and sits as a Court of Appeal, while in certain classes of cases it acts as a court of first instance. In practically every district there is an Alkali's Court, administering Moslem Law, under restricted powers, presided over by an Alkali (native judge) with two assistants. Young men who have studied the sacred law, many of whom come from recognized legal families and have done courses in the Law School, are appointed assistants, and from the senior of them the Bench is filled by the Emir. At the centre is the Court of the Chief Alkali, which is a Court of Appeal, and of the first instance as far as the city is concerned. Both this court and the Judicial Council have full powers to deal with serious cases referred to them from the inferior District Courts. Over forty thousand cases are disposed of in these native courts every year.

The greatest interest is evinced by the members of council in all branches of government; even the most modern and scientific innovations are welcomed, and their application by the technical staff is keenly followed. Motor transport has accelerated the dispatch of official business beyond comparison with the days of exclusively animal communication, though messengers in the districts

are still mounted on horses. A fleet of cars and lorries is owned by the Native Administration who employ a seconded European mechanic to keep them in order: they are constantly in use on official business. In and round the city the telephone has proved very popular and the system is being extended from time to time: the Native Administration utilizes some 30 miles of telephone wires between their offices and have their own exchange in the city, which is maintained by the Government Posts and Telegraphs Department. The installation of electricity has made possible the use of various up-to-date devices such as power-mills in the prison for grinding corn for prisoners' food, circular-saws, planes, and various tools in the workshops. All these are operated by local natives under European technical supervision.

Though the members of council work in old-fashioned offices of mud with vaulted roofs and thick walls, modern office equipment is at their service, and typewriters—English or Arabic—are worked by long-robed Mallams who file their papers in the latest steel-filing cabinets. The use of forms printed in the Emirate Press has accelerated and simplified business and permits of rapid analyses of facts and figures.

The Emirate is divided administratively into twenty-seven districts of varying sizes and population, an average one being of about seventy-five thousand persons. Each of these districts is under a headman appointed by the Emir, in some cases from families territorially connected with the District, especially in the case of some of the marcher districts, in others from one or other of the ruling families or from among the more distinguished of his officers. The District Head, who is in close contact with the Emir through the Madaiki, is responsible for the executive side of the administration with the aid of the village headmen and their elders. He superintends the collection of taxes, both general and on cattle, and remits the proceeds to Kano: he is responsible for the good order and peace of his district and supervises the departmental activities going on in it—such as public works, agricultural, veterinary or medical work; he is aided by a staff of native scribes. The language of the people and of the administration is Hausa; a certain amount of Arabic is in use in official correspondence and in legal affairs. In those printed forms which are used by the old type of scribe Arabic is employed, but there is an increasing use of Hausa in English characters, and some departmental forms are bilingual in Hausa and English. The maps of the Emirate have, in addition to the ordinary copies in English characters, Arabic versions for the convenience of the senior officials who are not literate in the former.

Most of the District headquarters are accessible by motor from Kano, as the whole Emirate is covered with a network of fair roads, of which some are excellent; some suffer from difficulties of terrain, especially in the more sandy areas: the greater part of the roads radiate from the centre so that the Emir and his staff can reach any important point by car in a day at the most. The Nigerian railway traverses the Emirate from south-west to north-east; until recently Kano was the terminus of the single line from Lagos, but now the line has been continued for 143 miles to Nguru in the Bornu Province, following the valley of the Hadejia River.

The ancient city of Kano was first inhabited, it is said, by Hausa ironworkers who settled at the foot of the laterite hill (Dalla) to the north of the market where

iron ore was readily obtainable. The settlement increased in prosperity and was a place of importance in the fifteenth century long before the coming of the Fulani. Whether its foundation brought the trade routes or whether it was already an intersection of more ancient caravan tracks is not clear, though there is little doubt that there was a considerable trade with the Mediterranean before the sixteenth century. The Fulani movements at the close of the eighteenth century filled up the area south of the market, and to this day this, though the population is no longer exclusive, is known as the Hayen Fulani (Fulani Quarter). The market is therefore more or less in the centre of the city; though it covers more than 15 acres, it is always filled to suffocation by the press of buyers and sellers, and the administration of its many hundreds of stalls presents considerable difficulty.

The official population of the city in 1932 was over 83,000 persons (only natives live within the walls and a few Arabs); this is a minimum figure, and the true total is probably higher. In the dry season there is a floating population of native traders from all parts, including large numbers from French territory, which is estimated at about 25,000; there must also be at least that number of daily native visitors from the home districts when travelling is easy in the dry weather and the crops are ready for disposal.

It is a walled city, as indeed most of the principal places of Northern Nigeria are; even the market towns in the districts are surrounded by ruins of walls, some of which are massive while others are hardly more than low mounds. The city walls themselves are now for the most part decayed; though there are places where they stand more or less as they did, the greater part of the 12 miles' circuit is a mound from 30 to 50 feet high. Originally the high bank was surmounted by a crenellated mud wall, leaving a way immediately below and behind it wide enough to take mounted men. The fifteen gates with which the walls are pierced are in effect tunnels through the mound; some of them have been widened to take motor transport, but some are still as narrow as they originally were, with a bend in the passage to aid the defence. They are still closed every night with old gates of timber covered with cow-hide or iron plates, each controlled by its own gate-keeper living just within the wall. Near the gates the wall is still maintained.

Over one-third of the 16 square miles within the walls is covered with houses: the remaining land mostly to the west and north is closely farmed. There are remains of at least three old wall systems, one behind the other, though part of the eastern wall appears to have been common to all. In these farm lands, to the west of the houses, rises the flat-topped hill of Goron Dutsi, about 250 feet above the general level, from which a fine view is obtainable; in every direction the great plain stretches unbroken, except for the hilly area in the south-east. All the farm lands within the wall and in a considerable area adjacent to them are worked by city people, though the majority of them live on the profits of their trades and occupations and farm little, if at all.

As all the architecture within the city is of mud, a most impermanent but temporarily effective material, there is little that is ancient though much that is impressive among the buildings. The Native Treasury and part of the Emir's residence are among the oldest buildings, though probably even these are hardly one hundred and fifty years old. There is scarcely any thatch, the

usual native roofing—possibly because suitable wood for rafters and good grass are rare in the neighbourhood—and the roofs are of flat mud, slightly domed to allow the rain to run off. There is hardly any corrugated iron in use, and what there is is laid nearly flat and surrounded with a low parapet; the concrete buildings conform to the native architecture all around them, though the problem of flat concrete roofs has still to be satisfactorily solved in a land of great extremes of temperature. The insides of the better-class houses are vaulted in mud, reinforced by the wood of the fan-palm, which is not readily destroyed by white ants, a very prevalent pest. The doorways are finished off with heavy square-headed weather-mouldings, which are one of the more pronounced features of this form of building.

Until quite recently the houses were built very close together and all traffic, which was perforce only by horse or on foot, was through narrow winding alleyways, at once footpaths, sewers, and watercourses; goods were carried on donkeys, oxen or camels, or on the head, as is still the case, where motor transport is not used. During the last decade wide motor roads have been opened through the city on a definite plan, radiating to the gates from a circular road round the market, and a scheme exists for developing this system together with a network of minor motorable ways as opportunity permits. Such a plan is of course linked with the surface drainage of the city.

A characteristic of the place is the "borrow pits." Since all building is in mud, and extra effort is not popular with the inhabitants, the earth required was obtained as near as possible to the site; the result has been that the whole of the inhabited area has been deeply pitted with excavations; some of them are only a few yards across, but some cover several acres, and almost all are at least 20 feet deep. There is of course no drainage from these yawning pits, apart from the natural seepage which is slow, and the water which collects during the rains, though at times producing the most picturesque effects, breeds vast swarms of mosquitoes and, being an obvious dumping-ground for refuse, is a source of pollution and disease. The overflow from them after heavy rain adds to the difficulties of the alleyways. One of the developments of the city sanitation has been, and will be for many years, the immense task of filling in these pits, as only a few of them will answer to drainage. When they are filled in and made into tree-planted open spaces the disposal of the surface water, which they have collected in the past, becomes part of the general problem of drainage. Special areas which are easily drained are being set aside for future building-mud requirements.

It is the custom in most of the larger Hausa towns to have farms among the houses wherever land is available, but fortunately this is not the case in Kano, and there are large open spaces covered with short grass which are the grazing grounds of the local livestock, and in some cases the playing fields of the schoolboys and others. There are many delightful views across these open spaces of the flat-roofed houses against clumps of date-palm or baobab.

The average population of a Nigerian native town is under ten thousand persons; some of the larger centres are of the order of twenty to thirty thousand, but these are few. The size of Kano has added to the difficulties of the urban administration. There are 137 historic wards in the city, some of them containing over 500 adult males, others only a handful of men; the administration

is based on these small wards, which for convenience are grouped into four divisions, each of which is subdivided into a number of sanitary areas which also form the framework of the police organization. These four divisions, with a fifth covering certain extra-mural areas to the east, are under the Galadima of Kano, who controls all the city activities on behalf of the Emir, and is in constant touch with them by telephone; through the heads of the divisions he collects the general taxes and water rates and maintains the peace; he supervises the city police, the market, the prisons, and sanitation, and deals with the many problems arising.

Outside the walls is the European area, which is not under the jurisdiction of the Emir, consisting of trading and residential zones; these, with the police, hospitals, barracks, railway yards, aerodromes, and all the other departments of the central Government, cover an area of 5 square miles, and are formed into groups of buildings separated by wide belts of cultivated land; there is a population of over 360 Europeans and Asiatics and 6600 natives of various races. The scattered nature of the township is due partially to fortuitous growth and partially to planning. The actual trading zone covers the widest area and is filled with well-built stores, banks, and offices. As Kano is on the obvious route to the Zinder area of the Colonie du Niger there is a French colony there to deal with the transit traffic. The township, as it is called officially, has been settled for many years, and there are in it good tree-lined roads and various amenities. To the south, 2 miles away, is a country house of the Emir situated on his farms, known as Nasarawa, where are also the Residency and administrative offices.

The administration of the Emir obtains a substantial income from taxation and other sources from the great population of the Emirate, and as a result he is able to maintain very up-to-date services in such departments as medicine, education, and works. Recently part of the accumulated savings were spent in the construction and installation of a water and electricity scheme on a large scale. A power station has been built on the Challowa River (part of the Hadejia River system) about 8 miles south of the city, and thence water is pumped from wells sunk in the sandy bed of the river to the top of the western hill (Gordon Dutsi) in the city. From this point gravitation takes it to the numerous standpipes scattered in the inhabited area where it is used free by the people. A low water rate is levied on the natives living in the city for this service, while other consumers receive a metered supply on payment. It is too early yet to estimate the effect of this supply of pure water on a city where in the dry season water has been more or less a luxury, but in time it must have a far-reaching influence on its health. From the power station electric current is brought to the city; over 50 miles of streets, many private houses, and all offices are lit by it, and current is sold to individuals in the township.

The waterworks and electricity supply are under the control of a European manager who, with the rest of his staff, is directly employed by the Native Administration. Owing to the highly technical nature of this work there is of necessity very close European supervision, and many of the more responsible employees are still natives of the Southern Provinces, though Kano men are being trained for the future: the financial side however is carried out in the Native Treasury under the control of the Ma'aji, and there bills for supplies

are issued and payments are made, as is the case for all other financial transactions of the Native Administration. About a quarter of a million sterling of general Revenue is handled here every year, and the accounting side owing to the varied activities of the Emirate is very involved and follows the most modern methods: the use of cheques for all possible payments has been a great convenience.

The gigantic question of the health of the population is being faced and foundations are being laid for future expansion. In the city annual additions are made to the hospital at Shahuchi, which will shortly be a very completely equipped unit with separate portions for male and female patients, mutually independent in personnel, buildings, and equipment. There is a medical officer in charge who is lent by the Government, though the staff and the non-technical stores are under the charge of a native warden who represents the Emir and co-operates with the Medical Officer. (A similar arrangement obtains in the other technical departments.) In the districts are established "bush" dispensaries under native dressers, who administer the simple treatments and dressings under the direction of a touring medical officer.

The Survey and Printing Departments of the Native Administration call for special comment. These are housed in dignified mud buildings outside one of the southern gates and started from very small beginnings about twenty years ago. Gradually built up as the native staff became used to the work and its objects, it is now one of the essential features of the administration. The Survey Department is responsible for the farm survey which records the ownership of every farm within roughly 30 miles of Kano; on this the land tax is assessed and imposed, and its revision is a matter demanding constant attention and close accuracy. Apart from this there is a topographical survey of the greater part of the Emirate, and at present sixteen sheets on a scale of 1/62,500 have been published and work on others is proceeding. Printing of maps for other Native Administrations is also undertaken.

The city has been surveyed and there is an accurate plan on a scale of 1/480 in sixteen sheets which has been reduced for convenience to two plans on smaller scales. All this (apart from the major points which are in the Nigerian framework) and the topographical survey including the drawing and final printing, is carried out by the native staff under the supervision of one European, Mr. H. Morphy, of the Government Survey Department, seconded for the purpose. He also supervises the printing press which, beyond supplying all the forms in Arabic, Hausa, or English, required for daily use by the Kano Native Administration, does an immense amount of work for the others, issuing several millions of forms every year.

At any time there are small parties of native surveyors at work in the field without any more direct control than is found in the final office scrutiny of their work. Here, as in the other departments of the Emirate, the native staff is controlled by senior natives, and it has been possible, when the European is absent on leave, to run the department with only occasional visits by an administrative officer. In this way a reasonably accurate survey of the Emirate has been obtained without the vast expense inevitably attending a European staff.

This department also records the usual diurnal statistics. The climate of

Kano approaches that of desert conditions and is drier than that of most Nigerian stations. The extremes of temperature vary from about 45° in January to 110° in March and April. The rainfall is confined to the (English) summer months, and rarely starts before May and ends before October except for a few storms; it amounts to 33 inches on the average. The country of course becomes entirely dry and parched before the rains. The climate is not unhealthy for Europeans for short periods of residence.

The daily press, which has begun to have a considerable influence in the literate areas of the Southern Provinces, has no place in Kano, nor, for that matter, in the whole of the Northern Provinces except among individual groups of natives, such as clerks, who are dependent on the Lagos papers for their news; a new development has however recently taken place in the quarterly publication of a polygot official illustrated newspaper at Kaduna, in which news and articles prepared by native committees in the Provinces are printed. This publication is very popular among the literate northern natives.

The Native Administration, though it is part of the machinery of the Government of Nigeria under the advice of the Resident and his staff, is not concerned with those Government activities that are pan-Nigerian (except to benefit from them), such as the Posts and Telegraphs, the Customs, or the Railway Departments. It has however its own police in two distinct bodies, city and country, and these have no connection with the Nigerian Police, of which there is a detachment in the township for local duties, though close touch is maintained and information exchanged; it works in harmony with the other Native Administrations in sending men to Kaduna to the central training school and contributing to a central finger-print bureau there.

There is no space to deal with other numerous activities of this Emirate. Progress on carefully planned lines has been uniform, and it is difficult to recognize in the present organism the descriptions of the Kano of the first occupation thirty years ago. And yet for the most part the native institutions and methods of government then found have been preserved, though pruned of their excesses and weaknesses, and suitable modern developments have been grafted on to the old framework.

JOHANNES COCHLAEUS AND A PROBLEM IN SIXTEENTH-CENTURY CARTOGRAPHY

E. P. GOLDSCHMIDT

THE woodcut world-map with the legend "AMERICA," preserved in the John Carter Brown Library at Providence (R.I.) since 1901, has been something of a puzzle ever since it became known. It is an almost identical replica of the "modern" world-map in the Strassburg Ptolemy of 1513; but one of the minute differences noticeable is precisely the addition of the word "America," which is not found on the New Continent on the Ptolemy map. The claim put forward for it by its discoverer, the late Henry N. Stevens, that this map is the earliest with America on it, has been received with a good deal

of scepticism ever since it was advanced. At the time the claim was made it was, according to the state of knowledge prevailing in 1899–1901, quite defensible, since the earliest known world-map with the legend "America" was then the Apianus map of 1520; it could even reasonably be contended that this unique variant of the 1513 map might be an earlier trial rather than a later copy of the map as it appeared in the Strassburg Ptolemy. But after the discovery in 1901 by Professor Joseph Fischer of the large Waldseemüller map of 1507, this map was obviously dethroned from its pre-eminence. Nor did Mr. Stevens's elaborate monograph, which he published in 1928,[1] and in which he sought to vindicate the priority of his map against all comers, carry conviction to all readers.

The critical reviews by Father J. Peitz in *Petermanns Mitteilungen*, vol. 76 (1930), and by Professor L. C. Karpinski in the *Geographical Review*, vol. 20 (1930), quite conclusively disposed of any contention that the J.C.B. map could reasonably be supposed to be earlier than the 1507 Waldseemüller map, and Peitz in particular showed on purely cartographical grounds that a map of this type could only have been designed between 1507 and the Carta Marina of 1516. But neither of those critics suggested any alternative explanation for the origin of the map under discussion. Both willingly conceded that Mr. Stevens's monograph was a valuable piece of critical research, and though it must be regarded as a case of "special pleading" it was an eminently fair and well-supported *plaidoyer*, bringing forward all the evidence that was pertinent and available.

The Strassburg map and the J.C.B. map are so similar that Stevens himself at first thought them identical, and after he had noticed the little differences he himself says, "The obvious first inference was that of two similar maps the one bearing the extra name America would naturally be the later."

The differences are the following :

1. The J.C.B. map, though practically identical in outline, is not printed from the same woodblock, as can be seen from the differences in the shading.
2. The legends on the Strassburg map are cut on the woodblock itself. On the J.C.B. map they are inserted in roman type.
3. The names America and Venetia are not found on the Strassburg map but appear on the J.C.B. map.
4. Five names are different on the two maps.
5. Eight names appear on the Strassburg map and not on the J.C.B. map.

The block being a fresh cutting makes it probable that the J.C.B. map was not printed at Strassburg, where the old block would be available, and by a very excellent analysis of the type employed, Stevens has shown that the J.C.B. map was printed at Nürnberg. His arguments from the watermark in the paper which he brings in to corroborate this conclusion are not of great weight, because the paper mills sold their products over a very wide area, and while the fact that the same paper with the same mark is found in Nürnberg books, notably in Dürer's 'Great Passion,' 'Apocalypse,' and 'Life of the Virgin' of

[1] 'The first Delineation of the New World and the first use of the name America on a Printed Map.' London, 1928. 4to.

1511, is interesting and confirms the evidence of the type, it would not in itself preclude the possibility of the same paper being used in any other town.

Much less, of course, can the evidence of the watermark be used to date this map, as Stevens attempts to do. He has found the same paper used in Nürnberg books from 1477 to 1511, so why should it not have continued in use for another thirty-four years? In fact, Professor Karpinski in his review of Stevens's book asserts he has found the same paper in an Ingolstadt book of 1540.

The evidence from the type is of very different weight, and my careful re-examination of Stevens's contention has convinced me that his identification is correct. The type is the Roman text type used at Nürnberg by the "Printer of the Sodalitas Celtica" from 1501 to 1510; by F. Peypus (who may be identical with the foregoing) from 1512 to 1520; by Hieronymus Hölzel (the printer of the Dürer books on the same paper) from 1503 to 1511; by J. Weissenburger from 1503 to 1506. There are slight differences in details of the type as it appears at different times in different printers' hands, but clearly all these slightly variant types are cast from the same matrix with now and then a fresh letter added, as is usual.

From the type again, as from the watermark, Stevens has tried to prove too much. To profess to be able to recognize a more or less "worn" state of a type of which we see only isolated words not normally set up in a form but wedged, probably even hammered, into holes cut into a woodblock, does not carry conviction to anybody familiar with such investigations. It is not possible even to be certain, as Stevens claims to be, that the words on the map are set up in the type as used by the "Sodalitas Celtica Printer" or by Weissenburger, *i.e.* before 1506, and not in the state found in the hands of Peypus and Hölzel, *i.e.* after 1510. To argue on such details as the appearance of a recast T in Hölzel's type while the T's on the map seem all to belong to the earlier casting is quite useless: for whichever printer supplied the letters to be wedged into the map, and thereby to be definitely spoiled for ever, would not pick out his latest and best letters for the purpose, but may very well have put a worn and discarded type case at the map-printer's disposal. Nevertheless, we can state positively that the lettering on the map is set up from type found in use in Nürnberg between 1501 and 1520.

Reverting now to the abovesaid "obvious first inference," and assuming as a natural explanation of the similarity of the two maps that the J.C.B. map was copied from that in the Strassburg Ptolemy, and copied as we see in Nürnberg, we have to ask ourselves was there anybody in Nürnberg who would have any reason or occasion to have such a copy printed in the years 1513, or 1514, or 1515, or thereabouts?

The answer is that there certainly was such a man, and that his name is Johannes Cochlaeus, the schoolmaster at the St. Laurence School.[1]

Johannes Dobeneck, born at Wendelstein, in Franconia, in 1479, matriculated in Cologne University in 1504, and latinized his name into Cochlaeus according to the fashion of the day, especially among young men seized with the rising enthusiasm for the modern humanist learning, and with the ambition to write Latin poetry. To these Cochlaeus very clearly belonged. About the

[1] See C. Otto, 'Johannes Cochlaeus: der Humanist.' Breslau, 1874.

same time the modern humanistic tendencies had gained a strong footing in the council of the city of Nürnberg, particularly since Wilibald Pirckheimer, Dürer's and Erasmus's friend, was given special charge of all matters relating to education and schools. In 1509 Pirckheimer and his friends, among whom Anton Kress, provost of St. Laurence, was prominent both as a partisan of the "New Learning" and as the foremost cleric in the town, had elaborated a new schedule of modern education for the Nürnberg schools; and in March 1510 Cochlaeus, still studying at Cologne, was invited by the school committee officially, and in a private letter[1] by his particular patron, Provost Kress, to come to Nürnberg and take over the foremost school there, that of St. Laurence, and to reform its curriculum according to up-to-date methods.

By the end of May 1510 Cochlaeus had accepted the appointment and was carrying out his radical reforms and modernizations with astonishing energy. What we know about his pedagogic principles we mostly gather from the dedicatory epistles which he prefixed to the "modern" schoolbooks he was busily issuing in rapid succession for the use of his boys. First of all, of course, a new Grammar ('Quadrivium Grammatices' Nürnberg, Jo. Stuchs, Kal. Mart. 1511), then a little handbook for the study of music, a subject dear to Cochlaeus, on which he had already written at Cologne in 1507 ('Tetrachordum Musices' Nürnberg, Jo. Weissenburger, July 1511). Next Geography: 'Cosmographia Pomponii Mele, authoris nitidissimi, tribus libris digesta; parvo quodam compendio Joannis Coclei Norici adaucta, quo Geographie principia generaliter comprehenduntur. Brevis quoque Germanie Descriptio, ad profectum Juventutis Laurentiane Norinbergensis imprimis, dein ad ceterorum quoque in litterarum studio successus nunc prima sui Editione in lucem profertur.'—Nürnberg, J. Weissenburger, Jan. 1512. 4to. Gothic letter, 58 leaves. Finally, in November 1512, a general introduction to Natural Science, Cosmography, and Physical Geography, based, according to the usage of the period, on Aristotle: 'Meteorologia Aristotelis, eleganti Jacobi Fabri Stapulensis paraphrasi explanata, commentarioque Joannis Cochlaei Norici declarata, ad foelices Philosophiae studii successus Calcographiae iamprimum demandata.'—Nürnberg, Frid. Peypus, 12 Nov. 1512. 4to. Rom., 100 leaves. In spite of its more general scope, this book again, and especially Cochlaeus's own contribution to it, is mainly geographical.

Cochlaeus continued as schoolmaster at St. Laurence's till the spring of 1515, when he left Nürnberg to accompany three nephews of Wilibald Pirckheimer to Bologna University as their private tutor. Later on, he became prominent as the most violent anti-Lutheran controversialist, and died a canon of Breslau Cathedral in 1552.

Cochlaeus's schoolbooks are interesting, for they are thoroughly fresh, personal, and original; his avowed departure from traditional mediaeval school routine was certainly no empty phrase. What distinguishes them from similar humanistic productions (of which, of course, in those stirring days of classical revivalism there were a great many) is the striking prominence they give to geography as a subject of school-teaching, a singular feature hardly paralleled in other modernized schools elsewhere. This emphasis on the importance and

[1] This letter is printed in full in J. Heumann, 'Documenta literaria.' Altdorfii, 1758, p. 7.

suitability of geography as a school subject did not merely rest on the personal predilections of Cochlaeus: it corresponded, as he himself points out, to the requirements of the pupils entrusted to him. The sons of the Nürnberg patrician families were destined to carry on the world-wide business relations which the great Nürnberg merchant houses entertained with all the chief ports and commercial centres of Europe. It corresponded also to the *genius loci*, for no other town has ever housed such a succession of prominent students of geography as Nürnberg, where Regiomontanus planned a Latin Ptolemy as early as 1472, where his pupil and literary heir, Joh. Werner, was the first to elaborate the mathematical bases of map-projection, where Martin Behaim, the practical navigator, made his globe in 1492, and Johannes Schöner his globes in 1515, 1520, and 1533, where Erhard Etzlaub printed his first road-map in 1501, where Conrad Heynfogel brought out the first German translation of Sacrobosco's Sphaera (1516), and Jobst Ruchamer that of Montalboddo (1508). But most important of all perhaps, in determining Cochlaeus's preoccupation with geography, was the interest of his principal patron, Wilibald Pirckheimer himself, whose lifelong studies in this field led to his great edition of Ptolemy (Strassburg, 1525), and to his own Germaniae Descriptio (1530), of which Cochlaeus's Appendix to the 'Mela' was in a sense a forerunner.

In November 1514 there appeared at Nürnberg an edition of the mathematical portions of Ptolemy's Geography, edited by Johannes Werner with a very valuable and learned commentary. Several of the contemporary Nürnberg geographers contributed their "applausus" to this important publication, among them Jo. Cochlaeus. His laudatory poem (on fol. liii) claims for Nürnberg some special divine favour in matters of geography and astronomy, dwelling on the value of the work of Werner, "Gualterus,"[1] and Bilibaldus [Pirckheimer].

The schoolboys at St. Laurence's, then, were being taught geography pretty intensively, and Cochlaeus in his dedicatory letters tells us very clearly how he taught them.

In his address to Pirckheimer, dated 25 November 1511, in the 'Pomponius Mela' (fol. E VI verso) he defends the study of geography as necessary to the understanding of the classics, and goes on to say:

[1] Gualterus = Bernhard Walther, born at Nürnberg *c.* 1430, died there 1504. When Regiomontanus settled at Nürnberg he became his munificent patron, and in his own house established for him an astronomical observatory, a mechanical workshop, and a printing press. When Regiomontanus left in 1475, and soon after died in Rome, Walther bought up his library and instruments from his heirs, and continued his studies and observations. After Walther's death Regiomontanus's famous library of mathematical MSS. was sold by his heirs, but a number of them are preserved among the most precious treasures of the Nürnberg library. Walther's astronomical researches after his friend's departure were by no means barren of results. He was the first to recognize the necessity of taking into account the refraction of light in observing astronomical altitudes; he first used a mechanical clock to time his observations, and first based his calculations on Venus rather than on the Moon in determining the location of celestial phenomena. Schöner and the other Nürnberg scientists utilised and published many of his observations and notes which he left in manuscript. From Schöner also we learn that he was an unfriendly and inaccessible old bachelor who jealously guarded his precious MSS. and instruments, and denied access to all students. (See *Allg. Deutsche Biogr.* XLI, pp. 97–99.)

> And if anybody should object that such reading could not be understood by boys only just initiated into the first elements of grammar, let them please remember that the entire subject-matter of this science can be perceived by the senses and that therefore the understanding of the scholars can be helped easily both by careful explanation by the teacher and by ocular demonstration of the countries. In fact I myself keep for this purpose three maps, two hand-designed ones and one printed map.

Indeed, Cochlaeus carried his practical geographical instruction even farther than that, for in the dedication of the second edition of his 'Quadrivium Grammatices' (Tübingen, Anshelm, 1513) he reports progress to his superior, the Provost of St. Laurence, Anton Kress, *d. dato* 1 August 1513:

> In Cosmography, beside the situation of the various countries, some of them have learnt to construct world-maps with the compasses and to draw them in the right proportions.

Clearly Cochlaeus possessed and used maps, knew how to construct them and how to employ them in teaching. He would be obviously interested in any new maps that came upon the market, and in any new developments in geographical science or discovery. And through his patron and friend, Wilibald Pirckheimer, such novelties would be within his reach as soon as anybody's.

That the latest reports about the new discoveries not only were familiar to Cochlaeus but roused his vivid and enthusiastic interest becomes apparent in both the geographical schoolbooks he issued in 1512. In both of them passages on the newly found America are found, indeed, in both of them one might say that, in view of the subject-matter in hand, a mention of America is almost dragged in.

In the 'Pomponius Mela' we find on fol. F1 in the first chapter (on the five zones) of Cochlaeus's additions and annotations to the preceding text of 'Mela':

> The unknown Zone. About the last of these zones, that of the Antipodes, nothing has so far been learned from the days of classical antiquity up to our time. But now in our lifetime, *Americus Vesputius* is said to have discovered that *New World* by sailing with ships belonging to the kings of Spain and Portugal not only beyond the torrid zone but even far beyond the tropic of Capricorn. And he says Africa stretches as far as that, and that this New World is quite distinct from it and bigger than our Europe.

And again in the 'Aristotle,' on fol. 62, once more in his chapter on the Division of the Earth into five Zones (Commentary on Meteora III, Cap. 2), Cochlaeus dilates on the extent of the inhabited World—much greater than it was supposed by the ancient geographers to be—not only in the East, in Africa, and in the North, but in "the new country of Americus, only just recently discovered [which] is larger than the whole of Europe."

If we have demonstrated so far that Cochlaeus was a man likely to see a copy of the Strassburg 1513 Ptolemy immediately after its publication; a practical geographical teacher who did employ printed maps in his lessons; a man keenly interested in the new discoveries and therefore as likely as any one to add the word "AMERICA" on the big new continent shown on the Strassburg map without any lettering; that he was resident at Nürnberg from 1510 to 1515, that is, during the period when the type used on the J.C.B. map was in use

there, we have, I think, established a *prima facie* plausibility that he may have had something to do with the map in question.

Can we go beyond this at all and fix the responsibility on him more definitely? I think we can, by examining the divergences in the nomenclature on the two maps and comparing them with the names used in the corresponding passages in Cochlaeus's geographical hand-books.

Stevens has given a very careful and exact account of these divergences. Two names appear on the J.C.B. map and not in the Ptolemy: America and Venetia. The insertion or omission of "Venetia" is a matter of taste entirely, since on this small-scale map there is no proper place to put it in and the location of that town would be equally familiar anywhere at any time. Cochlaeus has utilized the blank space down the east coast of the Adriatic to put in "Venetia." The Strassburg woodcutter did not put it in at all. The insertion of "America" I hope to have explained above by Cochlaeus's interest in the new-found continent. Why the Strassburg engraver left it out after he had seen it on Waldseemüller's 1507 world-map I cannot explain myself any better than Stevens, who suggests that Waldseemüller had in the meantime become convinced of the hollowness of Vespucci's claim to the discovery of that continent and repented of having suggested that name for it in his Cosmographiae Introductio. Whether this theory be fanciful or psychologically correct, it does not affect the argument; the fact is that "America" appears on Waldseemüller's 1507 map, but not on his 1516 Carta Marina nor on the 1513 Strassburg Ptolemy map which was engraved more or less under his supervision.[1]

Whatever "second thoughts" may have influenced Waldseemüller to abandon his own suggestion, the winged word "America" had passed his lips in 1507 and became the established name for the new world. And just as Apianus put it on his map in 1520, so Cochlaeus would show his knowledge of current literature and the 1507 map by having it lettered on his copy of the Strassburg map in 1513–14.

Of the eight omissions of names appearing on the Strassburg map but not on the Nürnberg map little can be made; nor does Stevens insist on drawing any weighty conclusions from these "additions." Two of them (Tropicus Cancri, Gottia) are quite indifferent, as Stevens admits. Of the other six, four are clearly omitted for lack of space on the Nürnberg map (Barbaria, Alba, extra Gangem, Cananor); the method of inserting the names in type did not permit of such condensation and crowding as the woodcutter could resort to if pressed for room; in fact, "Cananor" on the Strassburg map is almost illegible, as is also the long barbarous word "Bargungapara," in the Malay peninsula. The eighth case, "Rio de lago," is the only one that is interesting. The river in South-East Africa is clearly there with quite enough space for its name, but it has remained nameless on the Nürnberg map. I suggest that Cochlaeus left out the name because he had already one other Rio de Lagos in Africa, on the Guinea coast—a well-authenticated and certain Rio de Lagos this, so he did not trust the correctness of the name appearing again at the other end of Africa.

[1] Professor J. Fischer and F. v. Wieser suggest the same explanation for this striking fact in their publication of the two Waldseemüller maps (1903), p. 33.

When we come now to the "Five names entirely and intentionally different on the two maps" we arrive at more significant clues, I think. The names are:

Strassburg map	*Nürnberg map*
Sera	Cesare
Canaree	Fortunatae
Zanara	Cirene
Lithuania	Littovia
paticho S. galla	peri thos gallas

For one of these, Lithuania/Littovia, I can give no explanation whatever, nor does Stevens make any point of this variant, so we may neglect it. In Cochlaeus's 'Mela' (fol. K I) the country is called Lituania.

The other four divergences however are clearly the emendations which a humanistic schoolmaster would make, preferring the classical forms to the vulgar as found in the nautical charts. Two of them, the Insulae Fortunatae and Cirene, we find under these names in Pomponius Mela's text as edited by Cochlaeus (on fol. V and XXVI). Ceuta (in Morocco) we do not find in 'Mela,' so it does not occur in Cochlaeus's books either as Caesarea or as Sera, but clearly the classical schoolmaster would prefer Caesarea to Sera, just as he preferred Cirene to Zanara. Most instructive, I think, is the change from the (to me) totally unintelligible "paticho S. galla" to "peri thos gallas": equally unintelligible, of course, but quite erudite and Greek-sounding. This mysterious legend is found on both maps on the south coast of Arabia, and what it referred to I do not profess to know.

I think these changes of vernacular place-names to classical names and the "graecisation" of the barbarous "paticho S. Galla" were corrections made by the schoolmaster of St. Laurence when he indicated the lettering to be inserted in his map. From his letter to Kress in 1512 we can see how anxious he was to get hold of maps for his geography lessons. When the handy world-map of the 1513 Ptolemy came out it very naturally would suggest itself to him how helpful it would be if every one of his boys could have such a map—a simple matter in Nürnberg with its numerous expert woodcutters. So he had it copied simply by giving the original map to a woodcutter to cut again. But many of the legends on the Strassburg map were illegible, incorrect, or unclassical, and the ignorant woodcutter would only make matters worse in attempting to copy them. Cochlaeus therefore would prefer to put in the legends himself in type, so that he could see they were correct. So he went to his printer, either Weissenburger (who had printed the 'Mela') or Peypus (who had printed the 'Aristotle'), and asked for a case of old type to take away and use for this; in fact, the 'Aristotle' is printed in the very type found on the map.

This, I think, is the explanation for the Stevens-John Carter Brown map. The "obvious first inference" that the Nürnberg map is a close copy of the Strassburg map can be upheld as the correct theory, and what divergences there are all point to a humanist schoolmaster, who wished to present his boys with a map corresponding to their text-books: that schoolmaster was Johannes Cochlaeus.

DEMARCATION OF THE INDO-AFGHAN BOUNDARY IN THE VICINITY OF ARANDU

MAJOR W. R. HAY, I.A.

IN November 1893 an agreement was signed between the British and Afghan Governments defining on paper the boundary of the spheres of influence of the two Governments wherever they touched each other. The British representative during the negotiations was Sir Mortimer Durand, and the boundary in question has ever since been known by us as the Durand Line. Steps were at once taken to fix this line on the ground, and demarcation was successfully carried out along a considerable portion of the frontier. Owing however to conditions prevailing in tribal territory certain parts of the boundary line could not be visited, and much of it remains undemarcated till the present day. This article describes how one of the gaps—a very small but important one—has recently been filled in.

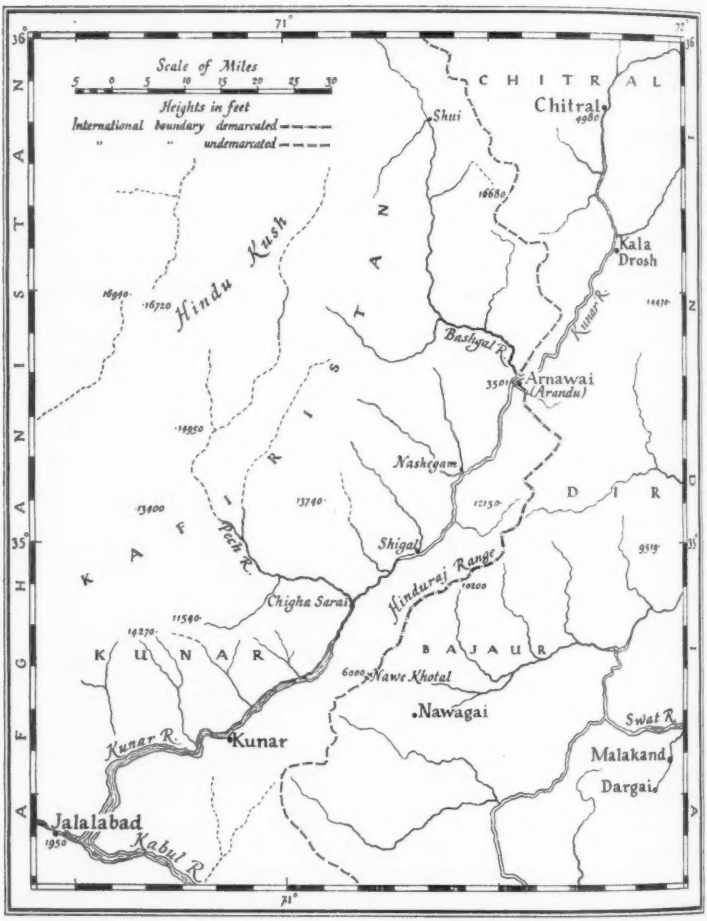
At the end of 1894 a Commission was appointed to fix the boundary in the vicinity of Bajaur and Chitral in accordance with the Durand Agreement. Our Commissioner was Mr. (later Sir Richard) Udny, and from the Afghan side Sipahsalar Ghulam Haider Khan was nominated. The Commissioners met at Jalalabad in December 1894 and proceeded up the Kunar Valley as far as Nashagam. Beyond this point they could not go, as the country was occupied by Umra Khan—"the Napoleon of the Frontier." The Commission remained at Nashagam till the second week in April 1895, during which time survey parties visited points in the hills on either side of the Kunar River and mapped as much of the country as was possible. Colonel (later Sir Thomas) Holdich was the officer in charge of the survey, and has described much of the work in his book, 'The Indian Borderland.'

The Commission were able to fix the boundary from Nawe Kotal, at the western extremity of Bajaur, to the northern limits of Chitral. This boundary however was not actually demarcated, but was described in an agreement, which we have since called the Udny Agreement, as a series of watersheds. There was one place however where the Commission realized that difficulties would arise, and that was where the boundary crosses the Kunar in the vicinity of Arandu, or Arnawai, as the Afghans call it. This spot was held by Umra Khan, and could not be visited. The Commission therefore prescribed certain subsidiary watersheds as the boundary, but added that demarcation would have to be carried out on the spot, and that variations from the line would probably be found necessary to protect the rights of local villages.

Ever since then the boundary at this point has been in dispute between Afghanistan and Chitral, the particular bone of contention being a small plot of land just south of Arandu known as Dokalim, which has changed hands several times. Negotiations have from time to time been started with the Afghan Government for the appointment of a Commission to settle the matter, but something has always occurred to make them break down. At length, as the result of protracted negotiations, a Commission finally assembled at Dokalim on 1 July 1932. The members of the Commission were Sardar

Habibullah Khan Tarzi and Ghund Mishar Saiyid Hassan Khan from the Afghan side, and Captain W. R. Hay and Shahzada Nasir-u-Mulk, eldest son of His Highness the Mehtar of Chitral, from the British side.

The work of the Commission was simple and was completed in a few days.

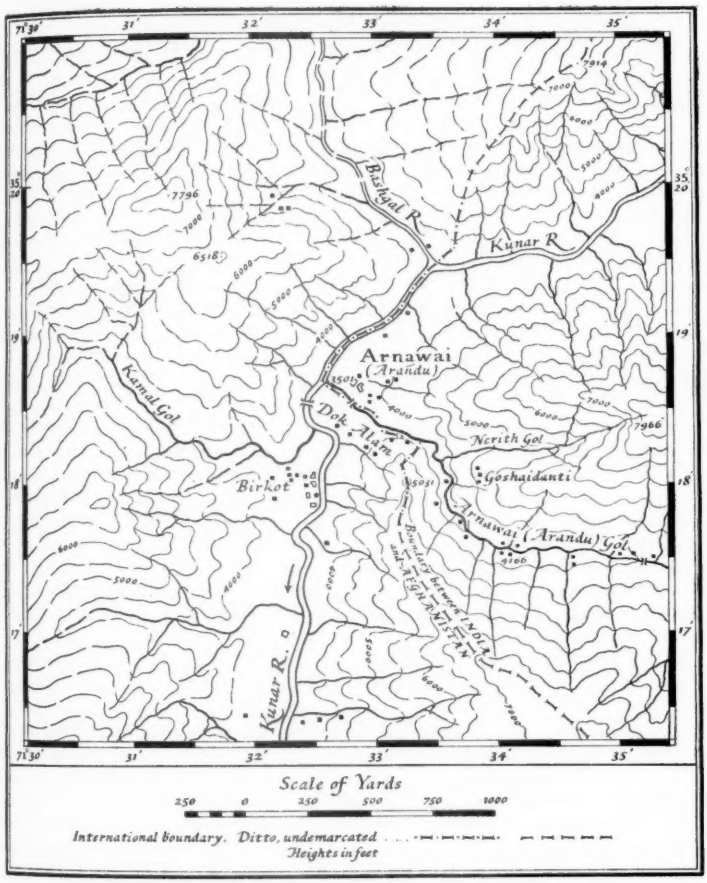


Sketch-map of the Indo–Afghan Boundary between Jalalabad and Chitral

In the Udny Agreement the boundary on the left bank of the Kunar River had been described as the southern watershed of the Arandu stream. This is clearly defined until the cultivated lands of Dokalim are reached. The Commission placed their first pillar on a prominent point on this watershed immediately overlooking Dokalim, and from there took the boundary almost due north to a point on the Arandu stream just above where it emerges from the hills,

leaving the Dokalim lands in Afghan territory. Four pillars in all were erected on this side of the Kunar River.

From this point it was decided that the boundary should run down the Arandu stream to its junction with the Kunar River, up the Kunar River to the junction of the Bashgal River, and thence north-eastwards along the watershed



Boundary near Arandu as fixed by the Commission

between the Bashgal and Kunar Rivers, *i.e.* the watershed already described in the Udny Agreement. As this watershed is badly defined for a few hundred yards just above the junction of the two rivers three pillars were erected over this length to mark its line and prevent the possibility of disputes arising. The negotiations throughout were conducted in a friendly spirit by both sides; the heat was severe, and probably conduced to their speedy conclusion.

Captain D. R. Crone, R.E., of the Survey of India, accompanied the British Commission, and thanks to the courtesy of the Afghan delegates, was able to visit points in Afghan territory and link up his work with that done by Sir Thomas Holdich in 1895.

NOTE ON SURVEY WORK WITH THE INDO-AFGHAN BOUNDARY COMMISSION, ARANDU, JULY 1932

CAPTAIN D. R. CRONE, R.E.

The survey party with the Commission consisted of one British Officer, one Indian Surveyor, and fourteen *khalasis* (instrument carriers, chainmen, and the like). When the Commission met it was decided that the map of the vicinity of the boundary should be on the scale of 4 inches to 1 mile. The nearest trigonometrical control was a chain of topographical triangulation executed for the 1-inch Chitral Survey in 1927. This chain at its nearest point to Arandu was 15 miles to the north-east and the stations 7000 feet above Arandu. Owing to the conformation of the ground the triangulation connection would occupy a full week, so that to economize time a base was measured by Wild invar subtense bar and extended, and sufficient points fixed around Arandu for the plane-tabling. The surveyor set to work on the mapping with the aid of these points whilst the British Officer attended to the provision of control for fixing the survey geographically and to the reconnaissance mapping on the 1-inch and ½-inch scales required to the south and west to connect with the boundary survey of 1894-95.

Owing to a very heavy dust haze which prevented triangulation for six out of the ten days occupied by the Commission, it was not possible to bring trigonometrical control into the area of the 4-inch map. An azimuth from the triangulation and the latitude and longitude of one point on the 1-inch map had therefore to serve instead.

Plane-tabling was normal in method but was handicapped by the great heat. A traverse by Wild theodolite and subtense bar was run up the Arandu Gol to fix the boundary pillar on its left bank, to avoid a difficult plane-table traverse. All boundary pillars were intersected in this traverse to afford a written description of the boundary.

Of the two trigonometrical stations visited, Busargat in Afghanistan, 10 miles west of Arandu and 11,400 feet high, provided the opportunity for connecting with Holdich's work to the west. The connection to the south was, thanks to the courtesy of the Afghan Commissioner, carried out on a mounted reconnaissance on the last day of the Commission. As the visibility was very low on account of dust no fixed points were visible and the survey was based on a compass and range-finder (80-cm. base) traverse.

In the ten days occupied by the Commission the survey party carried out 3 square miles of 4-inch plane-tabling, 39 square miles of 1-inch reconnaissance survey, 25 square miles of ½-inch reconnaissance survey, and photostereogrammetric survey which provided 100 square miles of ½-inch mapping and fixed numerous peaks over an area of 500 square miles.

THE ARCHAEOLOGY OF CENTRAL ASIA

ON ANCIENT CENTRAL-ASIAN TRACKS: brief narrative of three expeditions in Innermost Asia and North-western China. By Sir AUREL STEIN. *London: Macmillan and Co.* 1933. 9½×6½ *inches;* xxiv+342 *pages; illustrations and map.* 31s 6d

THIS latest volume by Sir Aurel Stein is a comprehensive summary of the results of his first three Central Asian Expeditions and of his Central Asian researches carried out during the last forty years. It is based on lectures delivered at the Lowell Institute at Boston, which were intended to give a condensed account of his archaeological and geographical explorations. All except one of Sir Aurel Stein's previous scientific or personal accounts of his travels are long since out of print and some are now unobtainable by the general reader. This summary would therefore be welcome if only because it renders easily available the more important results of Sir Aurel's work. In fact, it does much more than this, for the author has now reviewed in retrospect the whole of his journeys after the various collaborating specialists have examined the abundant material brought back by him. The book is by no means therefore merely a series of disconnected lectures, any more than it is just a popular book of travel. Sir Aurel Stein has brought together in one volume the most outstanding and most interesting of his discoveries, irrespective of their chronological dating during the last forty years; he has described the physical conditions under which they were made; and he has then turned his critical mind to the interpretation of the results as a whole. Each of the discoveries dealt with is illustrated lavishly by the most suitable photographs selected from his large collection already used in one of his previous books. This practice has enabled the publishers to include no less than 147 illustrations, many of them large half-tone panoramas, carefully annotated, and a number of magnificent colour plates showing specimens of ancient Chinese silk banners and tapestry. Throughout the book these illustrations are placed in close proximity to the text to which they refer, and, being numbered and referred to in the text, make the book extraordinarily vivid and easy to read. As the book is intended for the general reader, there are no references to detailed reports; the result is that the attention remains absorbed in the narrative throughout.

The first two chapters give a fairly detailed summary of the geography and history of Innermost Asia, and show the contact of Eastern, Western, and Indian civilizations. These chapters are themselves largely founded on research into ancient Chinese records as well as on the results of Sir Aurel Stein's own discoveries. The author then selects the most interesting of his routes into Central Asia, that by way of Chitral. In Chapters IV–VI he records the thrill of his first explorations at a sand-buried site, his discoveries there, his subsequent return and later finds, so that the exploration of the Niya site stands as an example of what occurred later at many other places, where details cannot be given in a summarized account.

After a brief chapter on the ruins of Miran, Sir Aurel takes us to Lou-lan and the dried-up Lop Sea bed, and tells the ever-fascinating story of his discovery of the ancient route across those desolate wastes, opened up under the direction of the Han Emperor, Wu-ti (140–87 B.C.). A broken copper buckle, an iron snaffle-bit, a scattered heap of bronze arrow-heads, a line of over a hundred Wu-shu copper coins, dropped from a leaky money-bag from the back of what may have been the last camel of the last caravan to use the route: these slender threads of evidence which led the explorer onwards to trace the route contribute

to the intense interest of this part of the story. Next is described the discovery of the ancient wall, an extension of the Great Wall of China, built by the Emperor Wu-ti, and fortified to protect the corridor in the Su-lo-ho basin from Hun raids. Sir Aurel Stein paints from the evidence of his finds in the old refuse heaps an interesting picture of the life of the ancient garrison of this Chinese outpost, the Hsien-ming Company of the Jade Gate, from which the silk-caravans used to start for the West and by which the jade-caravans from the Khotan district entered the comparative security of China.

The story of the discovery of manuscripts and paintings on silk in the walled-up chapel among the Cave Shrines of the Thousand Buddhas loses nothing of its interest in being retold; and the detailed negotiations and tactful persuasion displayed to secure these treasures for Western scholarship give an amusing indication of Chinese character. The explorations in the Nan-shan ranges and among the ruins of Turfan are treated in less detail, and the book closes with brief summaries of the author's subsequent travels on the western Pamirs, carried out on his third expedition.

The whole volume is of intense interest to geographers. If they have not already read the earlier volumes, they will surely wish to do so after reading this summary; while if they have already done so, they will find this volume an extraordinarily good précis of the whole. Only a few points of detail mentioned by Sir Aurel Stein can be briefly touched upon here.

The distinction between the "true desert" of Taklamakan and what the author describes as the "tame deserts" of Arabia, America, or South Africa is well brought out, while the actual formation of the Kunlun oases is most interesting. Early in the book Sir Aurel Stein alludes to "the Nan-shan, itself a continuation of the K'un-lun." There is a discrepancy here between the author's ideas and those of some other authorities. Sir Sidney Burrard, for instance, writes: "It is, however, only west of longitude 83° that the Kuen Lun faces the Tarim desert: east of this its branch, the Altyn Tagh, becomes the border range. . . . From Prejevalsky's descriptions the Kuen Lun appears to bifurcate at its eastern extremity into two ranges, the Burkhan Buddha and the Shuga." The Kunlun, that is, according to Sir Sidney Burrard, extends south of the Tsaidam swamps and Koko Nor, while the Nan-shan are of course north of these. Is it possible that the latter have ever had any geological connection with the desolate Kuruk Tagh or Pei-shan ranges and that such connection has been destroyed by the violent north-east winds mentioned in this district by Sir Aurel Stein, or buried under sand, as has apparently occurred to the Mazar Tagh in the Taklamakan?

Sir Aurel Stein stresses his views on the "desiccation" of Asia. It is as well that he does so, for he has often been misquoted to support a view he does not hold. He writes:

> "Everything in the orchards and arbours dead for sixteen centuries but still recognizable (Figs. 6, 45, 49); in the fences; in the materials used for buildings, etc., distinctly point to conditions of cultivation and local climate having been essentially the same as those now observed in oases of the Tarim basin similarly situated and still occupied.
>
> "Just as in the present terminal oases of the Tarim basin, so cultivation at those sites must have been entirely dependent on irrigation. Had not conditions of extreme aridity already prevailed in ancient times, it would be impossible to account for the survival in almost perfect preservation of a multitude of objects, very perishable by nature, in places so exposed as mere refuse heaps outside houses. . . . The climatic conditions of the periods immediately preceding abandonment must have been practically as arid as they have been since and are now."

Sir Aurel attributes the diminished volume of the water carried by the rivers of the Kunlun to the most obvious and most likely cause, namely, that the glaciers which supply those rivers have been undergoing slow but more or less continuous reduction in volume. In a later section of the book, Sir Aurel refers to the abandonment of the Dandan-oilik site as follows:

"Everything at the site pointed to its abandonment having been a gradual one, and in no way connected with any sudden physical catastrophe such as popular legends current about so-called 'sand-buried cities' of the Taklamakan have induced some European travellers to assume. The Sodom and Gomorrha stories related all over the Tarim basin about 'old towns' suddenly overwhelmed by sand dunes are more ancient than the ruins of Dandan-oilik. Hsüan-tsang had already heard them more or less in the same form in which they are now current. These legends are interesting as folk-lore, but in the face of plain archaeological evidence to the contrary, such as the examination of Dandan-oilik and every other ancient site in this region has supplied, scientific enquiry need have no concern with them."

Sir Aurel Stein also shows how in time of internal disorder, *e.g.* the epoch of the "Three Kingdoms," effective Chinese control over the whole of the Tarim basin was loosened, yet these territories still continued to be open to trade and cultural influences from both East and West. The reader will be tempted to make some interesting comparisons between the conditions at the end of the Han dynasty and those of the present. One interesting point which Sir Aurel Stein emphasizes is that the gradual abandonment of the old silk route was caused more by the opening up of the sea-route to China than to any physical difficulties of the route itself or degeneration in the stamina of the traders.

Enough has been said to indicate the outstanding interest of this concise summary of a brilliant period in Central Asian exploration. The description of the actual archaeological finds is every bit as interesting as the more purely geographical results. It remains only to add that the publishers, Macmillan & Co., and Messrs. Henry Stone and Son, of Banbury, are to be congratulated on the excellence of the printing, on the superb illustrations, and on the inclusion of the coloured map, which is published with the permission of our Society. The volume is more than worth every penny of its price. KENNETH MASON

THE NATIONAL GRID ON THE MAP OF LONDON

ORDNANCE SURVEY 3-INCH MAP OF LONDON. With Gazetteer (7×5 *inches;* 132 *pages*). *Southampton: Ordnance Survey Office.* 10*s*

THE 3-inch Map of London with Gazetteer recently published by the Ordnance Survey is the first to show on an adequate scale the National Grid as applied to London, and it is therefore of particular interest to study it in connection with the paper by Brigadier Winterbotham on "The Use of the New Grid on Ordnance Survey Maps," published in the *Journal* for July last. The grid is over-printed in red in squares of a kiloyard (1000 yards) and numbered in figures of two digits, the first two digits of the complete grid reference being omitted except at the corners of the map. The accompanying gazetteer gives the grid reference in three figures, that is to say, to one decimal place of a kiloyard; and it would, we think, have been well if the decimal point had been inserted as a guide to the user of the new system.

The grid references are to the initial letters of the names on the map; thus, the reference Piccadilly 409 064 indicates that to the nearest 100 yards the grid reference of the P in the name Piccadilly is 40·9 : 06·4. This method is well adapted to finding street names, but not so convenient in locating the principal buildings. Thus, for example, the grid reference to the Admiralty gives not the centre of the Admiralty building, but the position of the letter A some distance down the Mall. The gazetteer is interested principally in the names of the streets, though there is a short list of public buildings, a few churches, but no theatres, which are often so difficult to find. As a guide to the vast intricacy of London street names, the grid system must in course of time become indispensable, and one would like to be assured that the publishers of all maps of London will not only be allowed but encouraged to print the grid.

This is the more important since the newly published Ordnance Survey Map is unfortunately not of the first quality in design or execution. We may gather from the references to it in Brigadier Winterbotham's paper that it is in fact a map made some years ago for administrative use, and it bears no trace, except in the diagrams belonging to the cover, of the revolution which has been made in Ordnance Survey lettering during the last seven years. A few public buildings are blocked in in black, such as Buckingham Palace, the War Office, and the Horse Guards; but Saint James's Palace, the Admiralty, Foreign Office, and National Gallery are only outlined. The Air Ministry is not shown at all. Trafalgar Square is almost unrecognizable, with a huge symbol for "trigonometrical point on a building" (the Nelson Column) encroaching upon the western fountain and labelled "Monument," but no indication of South Africa House on the one side or of Canada House on the other.

The streets which are considered the principal lines of traffic are conventionally widened, and coloured in yellow ochre. But the whole map has the appearance of having been compiled by some one without any real knowledge of London. The main traffic is shown running north of Saint Paul's instead of south. Chancery Lane is as wide as Kingsway and the bottom of Park Lane wider than Hamilton Place and coloured equally. There is no distinction between the roadway across Hyde Park by the Magazine and the Broad Walk in Kensington Gardens. The great London termini are very inadequately shown by a square red symbol planted somewhere in great empty spaces which are really the areas of the stations. One would scarcely gather that St. Pancras has a frontage on the Euston Road. On the other hand, the Tube Stations are shown by round symbols in the middle of the road instead of in their actual positions, and recent developments are treated inconsistently. Piccadilly Circus and Hyde Park Corner stations remain in their old places, whereas Green Park Station, although not completed at the time of publication, is shown in its new place; while Down Street, which was closed six months ago, and Dover Street, then still at work, are included in the gazetteer but not shown on the map. "Oxford Street, Mayfair," and "Regent Street, Soho," are thus oddly distinguished in the former, and it touches our Society nearly that the name Kensington Gore does not appear either on the map or in the gazetteer.

But the main thing is that we now have a map of London with the National Grid, and it is open to the enterprising publisher of maps, directories, and guidebooks to build experimentally upon this foundation. It may also be the will and pleasure of teachers to introduce the grid into their local geography lessons, and to form an instructed public opinion.

REVIEWS

EUROPE

ON FOOT IN DEVON. By HENRY WILLIAMSON. *London: Alexander Maclehose & Co.* 1933. $7\frac{1}{2} \times 5$ *inches;* x+196 *pages; illustrations and maps.* 5*s*

The scene, the glorious coasts of Devon from Lynton to Hartland and from Sidmouth to Salcombe, is a background for Mr. Williamson on hike, the minutiae of his likes and dislikes, his wayside meals, titbits of philosophy, and his witticisms. Apparently objecting to ordinary guide books (except when he borrows a page or two), he omits most of the information which many—probably most—hikers would like to have. For this are substituted lively and often inconsequential remarks about birds and fish and beer and countless other transient and trivial matters. Surely there are permanencies in a countryside worthy of his indubitable flow of language. One is left with the impression that prior to printing nearly all the solid matter has been removed from these pages and the froth retained. In spite of this the light fare very cheerfully provided is likely to suit some palates.

S. E. W.

THE LANDSCAPE OF ENGLAND. By CHARLES BRADLEY FORD. *London: B. T. Batsford* 1933. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches;* x+68 [+96] *pages; illustrations and sketch-maps.* (*Drawings by* BRIAN COOK.) 12*s* 6*d*

THE BEAUTY OF ENGLAND. By THOMAS BURKE. *London: George G. Harrap & Co.* 1933. $8 \times 5\frac{1}{2}$ *inches;* 368 *pages; illustrations.* 7*s* 6*d*

THE PENN COUNTRY OF BUCKINGHAMSHIRE. [*London*]: *Published for the "Penn Country" Branch of the Council for the Preservation of Rural England by Evans Brothers* [1933]. $11\frac{1}{2} \times 8\frac{1}{2}$ *inches;* 128 *pages; illustrations and map.* 5*s*

Among the many collections of photographs of English scenery, Mr. Ford's takes a high place. He has made an admirable selection, demonstrating the great variety within a small compass of the landscapes of England. Until it is possible to render adequately harmonies of colour and atmosphere, these pictures will not easily be surpassed. He has on the whole avoided the better-known show-pieces and architectural triumphs. The many photographs of unhackneyed rural scenes are the best in the book, notably the pastoral serenity of Remenham, Berks, the heath above West Runton, and Swaledale. The open sweeping country of the Downs is also well conveyed. The omission of London and its "countryside," every year a more prominent feature in the English landscape, requires to be emphasized—to save foreign readers from possible disappointment. Mr. B. C. Clayton and Mr. H. Felton, among the photographers whose work is reproduced herein, are particularly to be commended. To write a text which might fittingly appear beside these pictures was no easy task: Mr. Ford acquits himself well—though he might have concentrated even more upon the main characteristics of each region, and eschewed strings of details and names. To turn over these pages recalls pleasant memories—and "England, bewitchingly small, lies complete at your feet."

The opening chapter of Mr. Burke's book raises hopes that are not altogether fulfilled. It is unnecessary to labour the point that he can write, and cannot be dull. Yet, after his fascinating introduction on the appeal of the English countryside and its place in the hearts of Englishmen, it is disappointing to find the remainder to consist of several itineraries embellished with the kind of historical and literary scraps which are only too familiar to readers of guide books. His

praise of the English countryside is almost lyrical, without glossing over less pleasant facts. He analyses the hold it exerts on the spectator—it is Americans who have felt it most strongly—as "loveliness of character: . . . in the peculiar beauty of England the ideal is made the actual," and, again, as "a tranquil sadness" and the "old and high cultivation that has humanized the very sods." The debt the countryside owes to the peculiar course of English history and to the comfortable climate might also have engaged his attention. All these delights, strengthened by the desire to escape from the cities, draw the townsman. It is more difficult to determine the appeal of the countryside to the countryman. Mr. Burke believes "the thing that binds him to England as to a religion is *the land*." But how far he appreciates its beauty, and how far he is held by custom and necessity, it would be beyond the scope of this review to inquire.

Mr. Burke dismisses the claim of Buckinghamshire to a share in the "Beauty of England" very cavalierly. The book issued under the auspices of the Council for the Preservation of Rural England will do something but not enough to right that injustice. The contributions by various pens are haphazard and arbitrarily arranged. An introductory geographical survey would have held them together. It also seems to lack a clear conception of the lines along which development is to be guided. Is the county merely to be thought of as a pleasantly situated dormitory for London? The reader however will acquire many interesting details from the papers. The examples of ribbon-development and the more exuberant atrocities which follow arterial roads must be seen to be believed. One or two of them might have been included in Mr. Ford's book by way of contrast.

G. R. C.

SCOTLAND'S RAINBOW WEST. By J. J. BELL. *London: George G. Harrap & Co.* 1933. 8 × 5½ *inches; 372 pages; illustrations and map.* 7*s* 6*d*

First we turn to the index and look up familiar areas—the ordinary test of a guide book's completeness. Then, satisfied, we look up our own favourite fastnesses, private hiding-places that must surely be considered inaccessible owing to the badness of the roads. One by one these too are exposed, advertised, boomed. Our own well-hidden glen with its peculiar local legends, the cave, the fern-shrouded streams, the ghostly corries, the solemn superhuman views, all our holy places are (we shrink from the fatal sentence) highly recommended to the tourist. That is the acid test, so bitter to the few, so delicious to the many, who, eager over the map, soon firmly press their automatic starters in, smiling already in anticipation. If they can only get there quickly enough, they too will be amongst the few. A remarkably complete guide book. The worst that can be said of it is that some of the photographs are out of date.

K. H.

AN AGRICULTURAL ATLAS OF ENGLAND AND WALES. Second edition, revised. Prepared by MALCOLM MESSER on behalf of the Agricultural Economics Research Institute, University of Oxford. *Southampton: Ordnance Survey* 1932. 25 + 3 *maps on scale* 1 : 1,500,000 *and Introduction.* 10*s*

The first edition of this atlas, published in 1925, was reviewed at some length in this *Journal* (vol. 68, pp. 343–45). The general features are unchanged, and for some account of them we may refer readers to that review. It seems more useful to note here some of the changes shown by this second decennial record of English agriculture. Its predecessor was based on the figures of the agricultural census of 1918; this is based on those of 1928. The arrangement, scales, and format of the maps are repeated; to the twenty-two maps of the first edition are added inset maps of the Channel Isles, and there are three new maps showing the distribution of sugar-beet, poultry, and employed labour respectively; while the fourth

basis map (market towns) is omitted. The introductory text has been carefully revised, and each section is expanded by a brief note on the changes since 1918. Some of the statistical tables, which are printed as insets on the maps, have been extended by the addition of an extra column.

The most extensive change, reflected in many of the others, is a reduction of the area of the arable land by nearly 2,000,000 acres and a comparable increase in the area of mountain and heath land (rough grazing). The total area under permanent grass has not increased very much; but it seems that the change noted has taken place in two stages: (*a*) the "laying-down" of former arable land to permanent grass, and (*b*) allowing former permanent grass to "tumble down" to rough grazing. These changes have been accompanied by a greater concentration of many crops, *i.e.* by a continuation of the process of "regional specialization" whereby the cultivators of each distinctive area tend more and more to concentrate on a small range of crops which are, for reasons determined by conditions of climate, soil, and accessibility to markets, most profitable in that area. On the map the most prominent increase in the area of rough grazing land is in a belt extending all along the South Downs and across Hampshire on to Salisbury Plain; though there has been a greater actual increase on the slopes of the Pennine and Welsh Highlands. The wheat area is reduced by a fairly general cessation of attempts to grow this crop in the north and west; and so there is a greater concentration on the good wheatland of Eastern England, from the East Riding of York to Essex. Similarly barley is more concentrated in the light-soil belts of the chalk and jurassic escarpments.

The annual census of livestock on agricultural holdings is taken in June. For some of the livestock, notably poultry and sheep, there are very considerable seasonal fluctuations in their numbers; and for store sheep and cattle there are also seasonal shifts from breeding to feeding areas. These maps inevitably fail to record such changes, and so fail to give a complete picture of the distributions. A winter map would show a larger proportion of both cattle and sheep in Eastern England, and of sheep on the lower lands. "The hill districts are the reservoirs of store sheep," a fact which is very strongly emphasized by this map of the distribution in June. Horses on agricultural holdings have decreased by 25 per cent.; there is no evidence here to show how far they have been replaced by tractors or motors.

Of the three new maps that of poultry shows, for the first time, the remarkable concentration of poultry farming in Lancashire and the West Riding of York. This is probably due mainly to the economic factor of ease of access to a populous consuming area; but there is no corresponding concentration near London, which appears to draw from a much wider area.

On the labour map each dot represents twenty-five employed men over twenty-one years of age. It is not stated whether these are only wage-earners, or whether the numbers include working farmers and small-holders. The distribution is fairly even over the cultivated land; but there are interesting small areas of concentration in the north of the Isle of Ely and in Middlesex. The former area is also one of concentration of peas and of sugar-beet and, though there is no map to show it, of small fruits; it has been affected by the development of the canning industry in recent years. The good land of south and west Middlesex, on the terrace gravels of the Thames and Colne valleys, is largely used for intensive market-gardening—another section which is not represented in this atlas.

An interesting fact which emerges from a study of these maps is that the outspreading of London in this decade has caused a distinct diminution in the areas devoted to agriculture to the north-west and north-east of the county of London. That county is left blank on all the maps; and on several of them its blank patch

has expanded noticeably into Middlesex and Essex. There is less evidence of its expansion south of the Thames. No other urban area has produced any noticeable effect on these maps.

Within its limits this atlas is almost complete. But we should like to see maps showing the distribution of small fruits and vegetables, and also of orchards. The statistical tables give the total agricultural area and the area under each crop mapped, both absolutely and as a percentage of the total area. But for comparative studies it is desirable that at least one table should also give the total area, including non-agricultural land and perhaps inland water, of the country and of each county.

1918 was the peak year of war-time regulation in this country. By 1928 agriculture had had some years of adjustment to world-wide competition. We trust that the atlas will be repeated ten years later; and for 1938 it may be able to record some effects of the recent changes in national policy towards agriculture. It has fully justified itself as an addition to our knowledge of our own country.

C. B. F.

ISLANDS OF THE WEST. By SETON GORDON. *London: Cassell and Co.* 1933. $9\frac{1}{2} \times 6$ *inches;* xvi+212 *pages; illustrations.* 15*s*

People who only travel by the aid of machinery can never spoil, because they can never reach, the mountains of the Caledonian Forest, where in summer there is no darkness. They will not flick their cigarette ash into eagles' eyries, nor will they ever meet Mr. Seton Gordon above snow-level in winter when the ptarmigan have turned white. Safe enough, away from all roads and hotels, he dozes in a ruined bothie on an uninhabited Outer Hebridean island. It is one o'clock in the morning. Suddenly he is wide awake. A storm petrel, with wings flickering mothlike, has walked over his hand. An event like that will be recorded in short unemotional sentences. At his best here and on the moors observing with the collie Dileas (which means Faithful), and, farther West, carefully recalling the talk of out-of-the-way lobstermen, noting down evidence about a fairy cow, or startling us with a terrifying climbing story in two paragraphs, he is less good when he drifts into an animistic philosophy and least good with his "Came a day of torrential rain," "Came the rising of 1715," "Came the soul-destroying Disarming Act"—a construction that sounds all right in the Gaelic, because there the verb must come first, but rather disconcerting in English. A pinprick of this sort can do no harm to so skilful and deservedly popular an author, who also should not have allowed such a misprint as *leth* on p. 2. It is certain however that lovers of the Islands and Highlands will be grateful for this book and especially for the photographs of the secret wild places that can never be too lonely and the simple people, these Arcadians, who are so contented. But are they? Ask the younger folk. What *they* want is more roads, more houses, and, no matter how red the roofs, more shops; trams, better harbours; trade, bustle, cinemas, more of what they call Life. Arcadian solitude may be Paradise for us who are rich enough to wander there and wander away again. For them it is not Paradise at all. K. H.

AGRICULTURAL SYSTEMS OF MIDDLE EUROPE: a symposium. Edited by O. S. MORGAN. *New York [and London]: The Macmillan Company* 1933. $9\frac{1}{2} \times 6\frac{1}{4}$ *inches;* xx+406 *pages; sketch-maps.* 25*s*

The scope of this book is wider than the title suggests, for the expression "agricultural systems" is employed, not in the restricted sense usual in England, but as a synonym for agriculture in general. The countries dealt with are Poland, Czechoslovakia, Austria, Hungary, Romania, Yugoslavia, Bulgaria, and Greece; and the chapters on each were compiled by nationals of the respective countries,

who were in all cases men with authoritative information and usually the respective Ministers of Agriculture. The editor, who is Professor of Agriculture in the School of Business, Columbia University, ensured a broad uniformity of approach by issuing a general scheme of treatment, and each chapter is prefaced by a brief geographical account of the country concerned and proceeds to deal with such subjects as land utilization; land reform; production and technique of farming; marketing; agricultural co-operation, taxation, and education; farmers in politics; farmers' income; and finally the outlook for farming in general. It will thus be seen that the book is intended, not so much for students of agriculture, as for students of economics and sociology, and to some extent for geographers.

Owing to the large number of facts and statistics which the book contains, it does not make easy reading, and in some cases the English is so peculiar that it is difficult to understand what the author really meant. As however each contributor delivered his chapter already translated into English, these lapses are understandable, if not excusable. The chapters are naturally also of somewhat unequal merit, mainly because the contributors have not always realized, or have failed to state, the aspects of agriculture which are unique to their particular country. On the other hand, several of the chapters, more particularly those on Greece, Poland, and Yugoslavia, provide a very illuminating supplement to the statistical material, that on Greece in particular giving just that human and vivid detail which could only otherwise be obtained by prolonged visits to the country. The account of the Greek peasant's working year, of housing conditions, of the types of implements and methods of cultivation, will prove of great interest to students of Human or Social Geography. The chapter on Poland gives a very interesting account of the contrasts in the standard of farming in the different parts of the country, and that on Yugoslavia emphasizes the persistence in that country of subsistence farming.

The book as a whole brings out clearly the almost mediaeval character of farming and peasant life in the greater part of East-Central Europe, in particular the survival of the open-field system and the low level of literacy. So primitive is farming in parts of this area that the authors of the chapter on Greece praise the compulsory three-field rotation as an improvement on the ordinary open-field system. Among the encouraging features common to most of the area may be mentioned the spread of the co-operative system in different forms and the establishment of schools giving definite agricultural instruction, particularly to young people.

M. R. M.

ASIA

KYOTO: its history and vicissitudes since its foundation in 792 to 1868. By R. A. B. Ponsonby Fane. *Hong Kong: Rumford Printing Press* (*London: Luzac*) 1931. $9\frac{1}{2} \times 6$ *inches; 434 pages; illustrations and plans.* 21*s*

This scholarly treatise, consisting of reprints of four papers contributed by Dr. Ponsonby Fane to the Transactions of the Japan Society in London, deserves a high place in the serious literature concerning Japan. It is primarily a work for the specialist who requires copious and straightforward information regarding the topographical and architectural development of Kyoto, but, though the author disclaims any attempt to deal with political events, it is at the same time of abundant interest to those who study the general history of Japan from the time at which she had completed the long process of absorbing Chinese culture and ideas until she began her present regular intercourse with the West.

As the place of the Imperial residence, and thus vested with a certain sacrosanct

quality, the titular capital did not figure to any great extent, during this period, in the forefront of what was at times a stormy history; but, if it did not dominate, Kyoto certainly reflected the course of events in Japan, and Dr. Ponsonby Fane's frequent incidental references to political intrigue, and on occasion violence, cast an interesting sidelight on the doings of the warlike chieftains who struggled for or monopolized power over the country at large until the days of the Tokugawa Shogunate. And even then, as this book shows, the history of Kyoto continued to be so frequently marked by disasters arising from flood, fire, earthquake, and pestilence that the reader may well question whether the tranquillity with which her name is associated was not more relative than real. E. H. DE B.

TELL HALAF: a new culture in oldest Mesopotamia. By Baron MAX VON OPPENHEIM. Translated by GERALD WHEELER. *London: G. P. Putnam's Sons* [1933]. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xvi + 338 *pages; illustrations and sketch-maps.* 21*s*

Imagination is an essential quality for the archaeologist. His problem is to reconstruct history, which is a thing of motion, out of material which is in its nature stationary. His actual finds are clues; what interests him are not the pieces of flint, pottery, statues, bronzes, in themselves, but the life and continual change which they represent, by which they were once cast casually on buried shelves of Time, where the archaeologist laboriously digging finds and uses them to reconstruct the living picture.

This work of imaginative reconstruction has been going on very rapidly of late in near and central Asia, and every discovery, while it throws light on its own immediate age and locality, opens up new and unexplored problems for future investigation. Baron von Oppenheim's book is important in both these aspects, for not only are the statues and reliefs found at Tell Halaf unique as artistic objects of the very greatest interest, but the theories which the author bases on their discovery open up the very obscure question of the pre-Sumerian and pre-Semitic inhabitants of the Euphrates and Tigris valleys. Apart from this, the book introduces us in a lively, simple style to a most engaging, adventurous, and enthusiastic personality.

It opens with the account of the author's first journey into upper Mesopotamia in 1899, and his stay with the great tribal Sheikh of the Milli, Ibrahim Pasha, in a guest tent that held 2000 men. Here he accidentally heard of the discovery of some statues near Ras el Ain, at the source of the Khabur river. He made a five-days' march to look at them, and tells in a casual way how he was attacked eight times by Badawin raiders on the way, but "succeeded always in coming to an understanding with them," and finally found his straying food and baggage on the third evening, encamped "in a regular fort" built with the camels and packs, where "it had been attacked many times, but luckily unsuccessfully." This was still the heroic era of archaeology in Mesopotamia, and it resulted in the discovery of the temple-palace of Tell Halaf and of its greatest treasure, the basalt statue of the veiled goddess.

In 1911 the author left the diplomatic service to devote himself to digging, and the serious excavation of the Tell was begun. Nearly one thousand camels were used to carry the expedition and its belongings across the desert from Aleppo, and endless difficulties with local labour and authority were overcome. Results appeared almost forthwith: "colossal animals, gigantic statues of gods, veiled sphinxes, and more parts of the façade." Most of this sculpture was found in an Aramaean palace, where it had been dug up and used over again by a later dynasty, and Professor Herzfeld, in an appendix at the end of the book, attributes it to a very much earlier date than that of the building in which it was found. Baron von Oppenheim ascribes it to the "Subaraic" civilization which he maintains to have

been general throughout Mesopotamia, north Syria, and in parts of Asia Minor and Persia at the time when the Sumerians settled and overlaid it in the south. The existence and identity of this civilization, which has hitherto been—erroneously, according to the author—qualified as Hittite, is the most interesting problem presented in this work. It is one which requires further investigation and confirmation from other regions, such as Elam for instance, where the Subaraic character of the pottery, etc., appears to be peculiarly distinct. The beaked type of face mentioned by the author in contrast to the Sumerian is still noticeable among mountain people in Luristan, probably descendents of the Elamites.

The area of the Khabur headwaters must have been a meeting-point of trade routes from very early times, and the author is justified in considering Tell Halaf as hitherto the "oldest and richest archaeological site in the great land of Subartu." It possessed a harbour, and must have been an important link on the main route from north Syria by Harran to Asshur. Somewhere about 2000 B.C. the Mitanni, an Aryan people of whom little is yet known, settled in this region. Baron von Oppenheim suggests that the site of their capital, Vashukani, is a field of ruins called Fekheria in the nieghbourhood of Tell Halaf, and we may look forward to many new and important discoveries when his excavations extend to this area.

The book is illustrated with photographs which make it invaluable for any student of primitive art who has not the opportunity to see the objects themselves in the author's own museum in Berlin. It is clearly translated, and there are six appendices and a useful index for experts, while the text itself is sufficiently lucid and simple to appeal to any reader who is interested in the early migrations and history of man. F. S.

AFRICA

CARAVANS OF THE OLD SAHARA: an introduction to the history of the Western Sudan. By E. W. BOVILL. *Oxford: University Press (for the International Institute of African Languages and Cultures)* 1933. 9×6 *inches;* [viii+]300 *pages; sketch-maps and facsimiles.* 21*s*

The picturesque title of this book, like the design on the wrapper of loaded camels in the gateway of a Sudanese town, needs to be interpreted by the second title, which gives the real clue to its contents: An Introduction to the History of the Western Sudan. Its twenty-three short chapters are packed with interesting matter written in a crisp narrative style, and tell a romantic story of what twenty centuries of time have contributed to the make-up of its principal tribes and successive kingdoms; of the Mandingo, Songhai, Tuareg, Hausa, and Fulani peoples, and the impact of Phoenicians, Jews, Arabs, Moors, and Europeans upon their culture and civilization.

Mr. Bovill reveals a surprising store of information about the interior of West Africa, contributed in the course of centuries by Arab, Portuguese, Italian, British, and other travellers and writers. He quotes frequently from them, and five pages of bibliography and lists of references at the end of every chapter prove the book to be the result of years of study, illuminated by personal knowledge of the country and sympathy with the people of whom he is writing. There are chapters also in which he theorizes, but there is never any confusion between theory and actual fact.

In addition to its historical information the book has a special geographical interest. It is illustrated with four reproductions of the map-maker's art in the fourteenth, sixteenth, seventeenth, and eighteenth centuries, as well as with nine

good sketch-maps. The first of these reproductions, a panel of the Catalan map of Charles V (1375), is something more than a map, since it includes charming pictures of the famous King Musa of Mali on his throne, and one of his Tuareg subjects mounted on a camel, turbaned and veiled, and carrying a *bulala* (whip) just as one sees his descendants to-day. Mr. Bovill shows that this map embodies the commercial knowledge of the Jew merchants of North Africa and Majorca, and that their enterprise in Africa was only checked when the wave of Jewish persecution in the fifteenth century spread through the Sahara. Europe's knowledge of the African interior was further increased by a succession of Arab, Venetian, Genoese, and Portuguese travellers and writers, such as Ibn Batuta, Malfante, and Leo Africanus; and of its coast by the Portuguese mariners, trained by Prince Henry the Navigator, who overcame their superstitious fears and opened the whole Coast of West Africa to the Bights of Benin and Biafra, and beyond.

There followed a period of two centuries when European knowledge of Africa stood still. The reproductions of Blaeu's map of 1665, and de Lisle's map (Elwe 1792) show much the same limitations and errors as the Ortelius map of 1570. Mr. Bovill shows how a single important error by Leo Africanus in stating that the River Niger flowed westwards instead of eastwards misled the map makers for three centuries. There is, it seems, a valuable lesson for all travellers to be learned from the fact that James McQueen, by careful inquiry from those who had personal knowledge of the country, namely, his Hausa and Mandingo slaves in the West Indies, was able to diagnose accurately the course of the River Niger and its termination in the Gulf of Guinea. McQueen's book published in 1821 gained no hearing, and rival theories about the Niger held sway until the problem was solved by the Landers in 1830.

Mr. Bovill elucidates a geographical puzzle which perplexed European princes, merchants, and map makers for many centuries. Wangara, the place and people, whence gold to the value of many millions sterling flowed across the Sahara to North Africa and Europe, was placed by ancient writers and map makers in so many different parts of the Western Sudan. Mr. Bovill locates Wangara, probably correctly, in the gold-bearing districts of Bambuk and Bure, about the headwaters of the Rivers Senegal, Faleme, and Niger. The confusion he attributes to the fact that Wangara is the name generally applied to all settlements of Mandingo traders, especially by Hausa-speaking peoples. Other forms of the name are Guangara and Gangara. Leo Africanus writes of a "kingdom of Wangara which adjoineth south-easterly upon Zamfara." Mr. Bovill identifies this Wangara with a town named Gangara in the southern part of Katsina Emirate, and the present reviewer can vouch for the fact that gold was being panned by calabashes in small quantities in the streams of that district as recently as 1912. But this little "Royaume d'Ouangara" occupies as much space in the ancient maps as any of the great Hausa states.

On the subject of the great caravans Mr. Bovill shows how trade bridged the Sahara and brought to the Sudanese tribes the elements of their culture, as well as the admixture of races which made that culture possible of achievement. To this admixture of races with negro stock, he attributes the pleasant temperament and likeable characteristics of the Sudanese peoples, to which so many travellers and writers, both ancient and modern, have given testimony.

Mr. Bovill's work will be a valuable book of reference, and the International Institute of African Languages and Cultures has earned the gratitude of all who are interested in West Africa and the Sudan, for its share in securing publication of this interesting book. E. J. A.

NORTH AMERICA

LÄNDERKUNDE NORDAMERIKAS: Vereinigte Staaten und Canada. By OSCAR SCHMIEDER. (Enzyklopädie der Erdkunde. Edited by OSKAR KENDE. Teil [27].) *Leipzig: Franz Deuticke* 1933. 10×7 *inches;* xii+454 *pages; illustrations and maps. M.*36

This considerable work, which may be described as an advanced geographical text-book of North America, impresses at once by its clarity, conciseness, and accuracy, and also by the comprehensive nature of its contents. The numerous diagrams are admirably conceived and executed, and the illustrations—collected together at the end of the volume—are always significant. For providing a comprehensive ground-work, this book is probably the best now available. The faults, or rather, what appear to the reviewer to be the faults, are in part inherent in the *genre* text-book, and in part, we think, derive from the general plan and organization of the work.

Little room has been allowed for descriptive matter; and we doubt whether the average student will be able to gain a true visual impression of any one of the regions herein so diagrammatically presented. It may be argued that a bare statement of structural genesis, together with an outline of the climate and vegetation, constitute a sufficient means whereby the physiographer may evolve a mental picture of the region concerned. But this is not always so, nor are all who should read this book trained physiographers.

And then there are the weaknesses inherent in the plan of the work. Only one-eighth of the book deals with the continent as a whole. The remainder is concerned with a regional treatment; the unit being the now well-established physiographical division. In each case the land forms are first dealt with; climate, settlement, and present development follow in the usual order.

Now there are two dangers in this quite conventional treatment, neither of which are entirely avoided in this instance. In the first place, material apt for correlation tends to become segregated in different watertight compartments. In this connection it is noticeable that such weakness as the book betrays lies largely in a lack of sequential correlation.

The other danger arises from the difficulty of apportioning perfectly the space to be allotted to the continent as a whole, as opposed to that allotted to regional treatment. We think that a good deal of the material which finds a place in the regional section could have been dealt with better in the section dealing with the continent as a whole. This is the more so since the regions are selected on a purely physiographical basis, and thereby a false emphasis is laid upon what are often mere accidents in a much larger region of some cultural homogeneity. To take a specific example. The physiographical details of Texas, and of the Lower Mississippi flood plain, and indeed the geography of these regions, is admirably treated; but on the South as a whole, or on the cotton belt as a whole, there is practically nothing. In the case of North America, where such large areas of the continent have suffered similar and contemporaneous conditions of penetration, settlement, and of economic development, the main lines of these phenomena, and indeed the whole geographical argument, become blurred, if the treatment is piecemeal.

There is an excellent select bibliography and an index. Mexico and Central America are not dealt with in this book, but are to be treated subsequently by the same author in a separate volume in the same series. Ll. R. J.

CENTRAL AND SOUTH AMERICA

BRAZILIAN ADVENTURE. By PETER FLEMING. *London: Jonathan Cape* 1933. 8 × 5½ *inches;* 414 *pages; illustrations and sketch-map.* 12*s* 6*d*

This is a traveller's narrative of altogether exceptional quality. The journey into the Matto Grosso which Mr. Fleming describes with such wit, charm, and modesty—almost too much modesty perhaps—formed one of several recent attempts to throw fresh light on the fate of Colonel Fawcett. So at least the author himself regarded the expedition; for he had been first attracted to the project by an advertisement in the Agony Column of *The Times* inviting candidates for a sporting expedition, in which the alluring words figured "if possible ascertain fate Col. Fawcett." He joined the expedition with a more deliberate interest in the Fawcett problem than had some of the rest, and as the prospects of doing anything effective faded away he and two others felt themselves more strongly committed to make an attempt, even if it amounted to little more than a gesture, leaving the main party on the Araguaya and technically resigning from the expedition. They make light of the adventure as a serious contribution to the Fawcett problem, but it has a definite importance, since it shows that three Englishmen with a few Indians, marching very light and with no better provision for the journey than Fawcett himself, were able to push up the Tapirape and across country towards the Kuluene to within 100 miles of Fawcett's last reported camp. They experienced but little resistance from Indians, and found game along the river. Away from the river there was grave danger of running short of water, and it might very well have been that with two companions in poor condition for marching Colonel Fawcett suffered as much from shortage of water as from the hostility of the native tribes.

This is the value, as a contribution to the Fawcett problem, of Mr. Fleming's book, which, he observes, contains nothing else of any scientific importance except "the discovery of one new tributary to a tributary to a tributary of the Amazon." As a piece of literature it is far more notable. 'Brazilian Adventure' contains many passages of real descriptive power, such that the reader carries away with him a more vivid picture of life in the interior of Brazil than he could get from many more sedate and technical volumes. But the outstanding feature of the book is certainly its humour—a sort of burlesque, allusive humour, just quickened by malice, which at its best reminds one of the reflective irony of Mr. Aldous Huxley in his travel book 'Jesting Pilate.' Nor is humour allowed to obstruct narrative: Mr. Fleming can tell an exciting story directly and well, and the final race downstream to Pará between Loyalists and Rebels conforms to the best traditions of the films. He makes continuous and effective fun of the conventional "Jungle Narrative," and records a nice aristocratic contempt for those traditional terrors of the Matto Grosso, the alligator and the piranha, almost persuading us as we read that they are indeed the harmless and pathetic creatures he depicts.

But at the end, in spite of all his efforts, we are left with the impression of a bold and vivid personality surrounded by a whole gallery of the people and problems and predicaments that made him laugh: the snake farm and the revolution at São Paulo; the circus at Goyaz at which after an hour's wait "a female tight-rope walker appeared and fell heavily, breaking her parasol"; the Tapirape Indians to please whom one said *Ticanto* "with desperate geniality"; the unexpected Archbishop touring his diocese in a big double-decker launch "like a floating Harvest Festival . . . a tall, disconsolate man in . . . violet stockings and a kind of Gothic bowler hat."

It is difficult to imagine that anybody who possesses a sense of humour will

fail to delight in this attractively printed book. Perhaps the illustrations are not very clear, nor the maps wholly adequate; but if you can write as well as Mr. Fleming, you can afford to dispense with professional-looking maps and illustrations.

D. C. S.-T.

CARTOGRAPHY

GEOGRAPHY OF CLAUDIUS PTOLEMY. Translated into English and edited by EDWARD LUTHER STEVENSON. With an Introduction by JOSEPH FISCHER. *New York: The New York Public Library* 1932. 17×12 *inches;* xvi+108+[29] *pages; facsimiles.* $60

It is remarkable, and not a little embarrassing to those responsible for the upkeep of libraries, that two of the most sumptuous modern works on Ptolemy's geography should have both appeared in 1932 with an interval of only a few months.[1] It is perhaps not a mere coincidence, for the study of the old geographer is in the air, and the knowledge that the great work of Joseph Fischer (reviewed in the *Journal* for July) was in preparation may well have brought to a head a project independently formed some years ago by Professor Stevenson. The two works are not necessarily rivals, for they cover different ground. While Fischer's is valuable for the learned commentary, no less than for the complete reproduction of the most important of the early codices, Stevenson's main claim to our gratitude is the provision for the first time of a complete English translation. He too supplies a fine set of the maps from an early MS.—the Codex Ebneriensis now in New York—but they are interesting mainly as representing the attempt of a fifteenth-century editor, Donnus Nicolaus, to supply a revised version for the use of his contemporaries.

The task of translating so big a work, written in language not always easy to understand and corrupted in places by constant copying, was an ambitious and formidable one, and we can only admire the industry and determination which has carried it through. The absence of a *textus receptus* added to the difficulty, for the translator was faced with the labour of collating different versions and making his choice between them. In his preface he says that his translation is based "upon the generally recognized best Latin and Greek texts," and we could have wished for a more explicit statement of his method of working—whether, for instance, he went back in the main to the original Greek. No doubt it would have been impossible, without immense labour, to give the particular source of the readings adopted, but without such annotations the resulting text cannot fail to lack authority to some extent. But no one who has not faced such a task has a right to carp at small deficiencies.

Besides the lack of an authoritative text, there must be endless difficulties, even to the best Greek scholar, in getting at the precise meaning of the author. Comparing certain passages taken at random with the text of Müller, we gather that frequently there has been no attempt at a literal rendering of either words or sentences—in fact that only the general sense is given by a paraphrase. This was perhaps unavoidable, and so long as the general sense is reproduced, no objection can be raised. But occasionally one doubts whether the translator has not slightly missed the author's meaning. To give an instance: in the eighteenth chapter of the first book where Ptolemy speaks of the difficulty of making satisfactory maps from the data of Marinus, the translation seems to imply that copyists rejected a map supplied by Marinus in his latest edition, working instead from the data

[1] It is almost entirely owing to the generosity of Mr. W. A. Cadbury that it has been possible to add these expensive works to the Society's library.

in the text. Did not the trouble consist in the absence of a map from that edition? Yet in the heading of the twentieth chapter we read again of the map "that accompanies" Marinus's work. Is not the meaning rather "that is made on the basis of" that work? But this is not to question the value of the translation as a whole. It will be most useful in giving a general view of Ptolemy's methods and ideas—a view obtainable from the Greek text only by such labour as few will have the perseverance to undertake. In doubtful passages, serious students can always have recourse to the original.

The freedom from serious rivalry between the two works is illustrated by the fact that Stevenson's is introduced by a valuable dissertation by Fischer, who gives in concise and handy form the main arguments and conclusions set forth at length in his own commentary. The English work has the general advantage of greater ease of handling, but even so it is something of a costly luxury, and one would like to see the translation issued also by itself, in a form that would make it more generally available.

E. H.

ECONOMIC AND HISTORICAL GEOGRAPHY

THE OLD STONE AGE: a study of palaeolithic times. By M. C. BURKITT. *Cambridge: University Press* 1933. $7\frac{3}{4} \times 5\frac{3}{4}$ *inches;* xiv + 254 *pages; illustrations and figures.* 8*s* 6*d*

This is a most informing and stimulating book, and will prove very helpful to students of all degrees and in all stages: it fulfils its object of giving a general impression of the whole subject in such a way that the reader may later wish to go into more detailed accounts. A new world outlook is rapidly being forced on prehistorians, and it seems certain that a new nomenclature, probably based on typological grounds, will eventually have to be devised: for the French system of classification, valid only for certain restricted areas of Western Europe, does not satisfy for Central Europe, and still less for regions farther afield. The area covered in this volume is primarily Europe and neighbouring countries, but we do not lose the general view of "the whole new edifice of knowledge." The general observer, indeed, is the special need of the time. Among valuable features of these pages are lists, tables, and classifications, the clear and sympathetic explanations given of such points as stratigraphy and typology, and the stress laid on others, as in the important chapter vi on Eoliths and the Dawn of the Stone Age. Incidentally the author does well, we think, to insist on the method of manufacture of stone tools in classifying them, on the right test for determining artifacts, on the use of the word "eolith" only for specimens considered to be artifacts, and on the fact that "no amount of reading is really a substitute for practical experience" of field work. Many cautions are entered against the fallacious assumption that similar cultures in different areas were contemporaneous.

S. E. W.

THE HORSE AND THE SWORD. By HAROLD PEAKE and HERBERT JOHN FLEURE. (The Corridors of Time. VIII.) *Oxford: Clarendon Press* 1933. $8 \times 5\frac{1}{2}$ *inches;* vii + 152 *pages; illustrations and maps.* 5*s*

This is the eighth volume of a series entitled The Corridors of Time, to be completed in ten volumes, and giving an account of human evolution from the beginning until the iron superseded the bronze sword and classical times began in the Mediterranean. This volume treats of the Near East from the fourteenth to the eleventh century, including the siege and sack of Troy—a turning-point—East Central Europe, Italy in the Bronze Age, West Central and North-West

Europe, and the Monsoon Lands of Asia; and relates first the decline and fall of the older empires, such as Babylon and Egypt, and the rise of later Powers—Greeks, Phoenicians, Hebrews. Archaeological details are accumulating rapidly, perhaps too rapidly, and on many points many different views prevail; but the authors of this book attempt a synthesis of the sequence of events which may serve as a working hypothesis to help both the serious student who is not a specialist and even the specialist who is in danger of losing a correct perspective of his own particular field. Thus it is argued that the period of transition from the Middle to the Late Bronze Age in Europe was a period of crisis of more importance than that from the age of bronze to the age of iron. Under the organization of men on horseback armed with swords civilization in Central Europe rose to a higher level and social structure developed greatly; but climatic changes, notably a cold and wet period, arrested progress. It is obvious that scholars like Professor Myres in 'Who were the Greeks?' are feeling their way among the archaeological facts very tentatively: their hypotheses are largely guess-work founded on possibilities rather than probabilities. But even so, in the present state of knowledge, they will serve the very useful purposes of pigeon-holing facts like the finds of various kinds of pottery, Dhimini ware, grey Minyan ware, etc. In the welter of new and unrelated facts, almost any reasonable attempt to introduce order is welcome, and these attempts are certainly courageous wanderings in realms half realized. These pages are far from light reading: often (*e.g.* p. 20) we get history in highly concentrated capsules. The story is very intricate and hard to follow, the harder because there seems to be little necessity in many of the inferences drawn. The retelling (chapter iv) of the much-told Tale of Troy and a digression (pp. 53–55) summarizing what is known as to the origin of the use of iron may be taken as good average specimens of the authors' methods and views. As to the remarkable evolution of culture in the West Baltic of the Bronze Age, the authors seem justified in attributing it to influences from outside, some sea-borne and others arriving by land, rather than to the autonomous development favoured by German archaeologists. It is impossible in a short notice to appraise justly pages so closely packed with facts and conjectures, but students will be grateful for the degree of cohesion suggested. S. E. W.

VITAL RECORDS IN THE TROPICS. By P. GRANVILLE EDGE. *London: George Routledge & Sons* 1932. $7\frac{1}{2} \times 5$ *inches;* xii + 168 *pages; illustrations.* 7*s* 6*d*

This hand-book has been published in the hope that it will be of service as a guide to the solution of the problems of introducing and maintaining suitable systems of vital statistics in the Tropics. As a text-book it has been thoughtfully prepared and lucidly written. The author has succeeded in avoiding a dry and difficult presentation of his subject; indeed he has managed to offer a very readable and interesting statement. After emphasizing the importance of reliable statistics both in administrative and medical work he proceeds to discuss methods of collecting the records, stressing in particular the need for and the difficulty in obtaining them from undeveloped and primitive districts. Chapters follow which deal with registration, records of births and deaths, and the presentation of the data collected. Finally the author shows how simple calculations can be made as regards birth and mortality rates.

One is inclined to wonder to whom the author is addressing his book. It would appear that he aims at the administrative and medical officers. But surely they do not to-day require instruction in the very elements of statistical work. Nor would it be easy to find such an officer who is not aware to the fullest extent of the need for accurate information concerning the people whom he has in tutelage.

The Annual Reports submitted by the medical authorities to their Governments show how alive the latter are to this essential aspect of good administration and the recent Census Reports prove how intense and progressively successful the research for demographic statistics has become. The book will however be useful to the cadet in the Administrative Service or to the medical student.

A. W. C.

DIE LÄNDLICHEN SIEDLUNGEN IN VERSCHIEDENEN KLIMAZONEN. Edited by FRITZ KLUTE. *Breslau: Ferdinand Hirt* 1933. 9½×6½ *inches; 208 pages; illustrations and maps. M.9*

One of the subjects selected for special discussion by the Geographical Section of the Wiesbaden-Mainz meeting of the Versammlung Deutschen Naturforscher und Ärzte (September 1932) was the geography of rural settlements in different climatic zones. The present volume is the direct outcome of the discussions: nineteen authors contribute that number of studies of the rural habitat, and most of the great climatic regions are included. The areas dealt with include Norway, continental Italy, Bulgaria, Albania, Crete, the Anatolian plateau, Kamerun, western Angola, East Africa, Siam, Sumatra, New Guinea, the Solomons, Australia, Canada, northern Central America, Brazil, the Argentinian pampas, and Chile. Some of the essays are too slight to have much value—for example, the nine pages on Australia or the ten pages (including an historical summary) on Canada, but the volume as a whole is of considerable importance. The Report of the Committee on rural habitat which was presented to the Cambridge meeting of the International Geographical Congress in 1928 was narrow in its scope and there has been a distinct tendency to adopt classifications—and nomenclatures—of rural habitat types based on the study of limited areas. Every school text-book quotes examples of the influence of climatic conditions on the character of domestic architecture—the flat-roofed mud house of arid tracts; the all-wood dwelling of forest areas; but a perusal of this volume will direct attention to the very different responses frequently found to identical climatic conditions. Much careful study is needed of the varying strength of tradition in determining the type of house erected by an immigrant race. The East Indian has brought his own type of dwelling to Trinidad; it may be difficult to distinguish a French residential street in Saïgon from one in a French provincial town. On the other hand, the Englishman in India has always erected—though the type has changed—dwellings regarded as adapted to climatic conditions. The contribution made by this volume to a fascinating and somewhat neglected aspect of human geography is an important one. L. D. S.

GENERAL

KILL: OR BE KILLED: the rambling reminiscences of an amateur hunter. By Major W. ROBERT FORAN. *London: Hutchinson & Co.* 1933. 9½×6 *inches; 320 pages; illustrations.* 18*s*

This is a hair-raising thriller. Major Foran, a hunter of large experience, describes the most exciting of his many adventures amongst the wild beasts of Africa and India. And thrilling enough though they certainly are, he has added to the excitement by including stirring tales told him by the more renowned hunters of the past. His record belongs to the old school of hunting, the time of Selous, Neumann, Sutherland and Cunninghame, when hard slogging was the order of the day and the modern frills of hunting were unknown.

Some of his experiences have been amazing, indeed almost incredible. He has

witnessed a thunderous battle between a tiger and a buffalo in which the horned ruminant not only gored his antagonist to death, but hurled its dead body into the air as though it were "a wisp of straw." He has photographed a lioness on a zebra's back, her fangs buried in the stallion's neck and her weight crushing the wretched beast to earth. He has watched a huge black-maned lion engaged in mortal combat with a bull buffalo, which battle ended in the buffalo first annihilating his enemy and then falling dead on the bleeding corpse. Truly there were giants in those days. We rarely see such wonderful things now! Many other kinds of exciting experience are related, such as roping rhinoceros, chasing lions on horseback, accounts of Masai who kill lions with spears, of Bunyoro who, instead of spearing them, round them up with sticks and literally thrash them into an undignified retreat. He preaches the true philosophy of sport. The genuine sportsman, he insists, is never a butcher of game. As for himself, he has never killed a living creature, save the crocodile, in order to satisfy the mere lust to destroy. His great joy has been in spending hours tracking down game or watching the animals in their natural surroundings. His hunting days, he tells us, are now over, and he can look back on them without any cause for shame. One thing however they have taught him. "If I had those years to live over again, I would not have changed them except in one single particular. And that would be to substitute a camera for a rifle." R. W. G. H.

A BEGINNER IN SAIL. By J. A. WILLIAMSON. *London: Edward Arnold & Co.* 1933. $7\frac{1}{2} \times 5$ *inches;* 160 *pages; illustrations* (*by* R. J. PUTTICK). 6*s*

It is difficult to imagine a better introduction to the details that are necessary to become an efficient amateur yachtsman than this book. The charm and romance of cruising are so deftly described that any one who reads this little volume will never be happy till he has experienced the same thrills as the author. The beginner is instructed by easy stages in the art of sailing an open or half-decked 18-footer in sheltered waters, until he becomes capable of navigating a 6-tonner down Channel. The description of the building of the author's *Content* is full of valuable details of the construction of an ideal small yacht. The discussion of deck construction is very practical, the question of rig is treated fully, and the query, Gaff or Bermudian, is answered very decisively in favour of the latter, although we feel that the arguments for Gaff are not given so fully as they deserve. All good yachtsmen have a certain feeling that it is not quite cricket to have an auxiliary engine; but even the most enthusiastic believer in sail finds that there are many conditions of wind and tide that make this modern innovation almost a necessity for owners who are limited by time, and whose week-ends would be spoilt if they had not power to call upon in an emergency.

Lights on small vessels are a perennial source of difficulty; but the use of a strong electric torch to throw its light on the mainsail is a method that should be remembered when circumstances find the yachtsman in the track of large vessels.

This is a book all yachtsmen will wish to have on their shelves. H. M. E.

THE MONTHLY RECORD

METEORITE CRATERS

Since Dr. Spencer read his paper on Meteorite Craters as Topographical Features of the Earth's Surface at our Afternoon Meeting in January last we have received several communications bearing upon this new and interesting subject. Dr. F. A. Melton and Professor William Schriever of the University of Oklahoma have published a paper in the *Journal of Geology* for January and February 1933 with the title "The Carolina 'bays'—are they Meteorite Scars?" For the following brief summary we are indebted to Professor Schriever. This abstract was, we understand, communicated to the American Association for the Advancement of Science, and perhaps inspired a paragraph in *The Times* of December 29 headed "When a Comet hit the Earth."

"An aerial mosaic map, made by the Fairchild Aerial Surveys, of 200 square miles of Horry County, South Carolina, revealed numerous smoothly elliptical large depressions the length of whose major and minor axes averaged respectively 2200 and 1400 feet. Field trips during June 1931 and August 1932 together with studies of many other aerial photographs of the Atlantic coastal plain yielded the following facts:

"1. Region of occurrence is the Atlantic coastal plain between Norfolk, Virginia, and the Savannah River, an area of approximately 40,000 square miles.

"2. Individual depressions are elliptical in shape.

"3. The long axes of *all* the elliptical depressions are parallel north-west-south-east lines.

"4. Elevated rims completely encircle some of the depressions.

"5. An elevated rim is invariably higher at the south-east end.

"6. There is a general increase of ellipticity with size.

"7. Double and triple concentric rims exist.

"8. The depressions intersect each other; completeness of outline is maintained sometimes by the larger and sometimes by the smaller.

"9. These depressions are at least as old as the Pamlico terrace of Pleistocene age and not older than the Waccamaw formation of Pliocene age. (The ocean has been over the area since the scars were formed.)

"All known geological processes were considered carefully but not any of them, either alone or in combination, could be made to explain these peculiar and striking depressions.

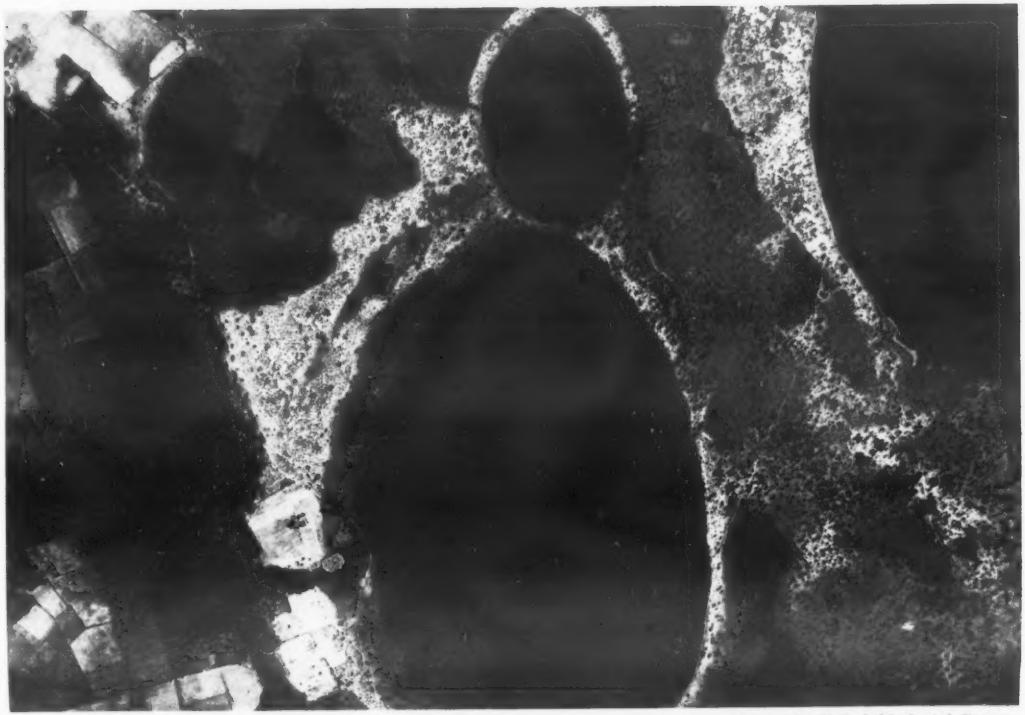
"The impact of a shower of meteors on the coastal plain is suggested as the agent which caused the depressions. It is shown that such a shower will account for all the facts qualitatively. A globular cluster of meteorites 400 miles in diameter could have produced the existing scars which number more than 1500."

The Fairchild Company have supplied the two photographs, one individual, one a mosaic of many, from which the plates accompanying this note are made.

It is important to remark that these formations have been submerged; there are old beach lines which cross and obliterate some of the bays: yet the low rims, described as of light sand, have survived the effect of submergence. The large shallow formations have much the appearance of certain lunar craters: but the latter have not the same common axis of elongation. It does not seem at all certain that if they are meteorite scars they are to be compared with meteorite craters caused by explosion. Indeed one might expect that an explosion crater would be very nearly round even if caused by the impact of a meteorite at a great inclination to the vertical; and there is no mention of silica glass such as that

Part of the aerial mosaic map of Horry County, South Carolina

Copyright Fairchild Aerial Surveys



Copyright Fairchild Aerial Surveys

Aerial photograph of one of the Carolina "bays" possessing three rims

described by Dr. Spencer from Wabar, which was so conclusive a feature of that discovery.

But a new discovery of silica glass has been made by Mr. P. A. Clayton in the Libyan Desert. A letter dated May 9 tells us that after carrying a triangulation across the sand sea west from 'Ain Dalla to the 25th meridian, he worked south to the Gilf Kebir and got his cars onto the plateau round the head of the wadi seen from the air last year (*Geogr. J.*, vol. 81, pp. 253 *seqq.*). Among the dunes Mr. Clayton found large quantities of fused silica looking like green bottle-glass in lumps up to 10 lb. in weight, of which specimens have been sent to Dr. Spencer.

On July 28 last the writer of this note had the good fortune to examine the Oesel craters under the guidance of Mr. J. A. Reinvaldt. The evidence of a tremendous explosion in the principal crater is impressive. Horizontal beds of dolomite limestone are violently dislocated and tilted upward, burnt limestone powder is driven into the gaps between the tilted slabs, and heaped against the inner wall, preserved from weathering by the mixed mass of dolomite fragments, burnt powder, and glacial clay that fell back into the crater after the explosion. The borings show undisturbed horizontally bedded limestone at a depth below the crater floor: the cause of the explosion was therefore external, and impact of a meteorite the only assignable cause, though no trace of meteoric iron has been found. Whether a meteorite of the stony kind would be strong enough to penetrate so deep is doubtful.

The small crater No. 4 has been cleared to the bottom, and two borings show that the rock below the floor is cracked and apparently burned to a depth of a metre and a half: cracked but otherwise undisturbed to about 3½ metres; and at 5 metres the normal dolomite. A funnel-shaped hole in the floor has been taken to be the scar of impact; but it is perhaps rash to infer from the size of this funnel the size of the meteorite. Small fragments of charred wood were found in the crushed dolomite above the floor, but no trace of iron.

Crater No. 2 has been described as "oval, slightly compressed." It is perhaps better described as two overlapping circular craters of different diameters. The difference is important, because if the explosion theory is correct the crater is very much larger than the meteorite, and whether the meteorite falls vertically or obliquely the crater is sensibly circular.

The group of meteorite craters on the island of Oesel is the only example hitherto recognized in Europe. They lie about 20 km. north-east of the pleasant watering-place of Arensburg (Kuresaare), and some 250 km. by road from Tallinn. The account given by Dr. Spencer (*Geogr. J.*, March 1933, vol. 81, p. 233) was based upon the paper of Messrs. Reinvaldt and Luka, published by the Geological Institute of the University of Tartu in 1928, and upon a later paper communicated to the Secretary in typescript. This paper, in English, has now been published by the Institute; it contains, beside details of the later borings, an interesting comparison between the Oesel craters and others recently described.

A. R. H.

Since the above was written we have received from Mr. Clayton the following fuller account of his discovery:

An occurrence of silica-glass in lumps up to 10 lb. in weight, smaller fragments being scattered over an area at least 80 by 25 km., has been discovered in the course of the work of the Egyptian Desert Surveys. A Survey expedition under Mr. P. A. Clayton was sent out in December 1932 to work in the unexplored area of the Sand Sea and Gilf Kebir, west of Major Bagnold's 1931 route, and found the glass on 29 December 1932. It occurs lying on the surface of the Nubian Sandstone in the sand-free corridors between the high north–south dune ranges

Aerial photograph of one of the Carolina "bays" possessing three rims
Copyright Fairchild Aerial Surveys

of the south-west of the Sand Sea. The largest lumps were found in approximately lat. 25° 25′ N., long. 25° 30′ E. The district is not easily accessible, as direct travel from Abu Mungar or Dakhla by car is impracticable. Water is only available at 'Ain Dalla, reached by a winding route some 500 km. long through the Sand Sea, or at Kufra Oasis, some 300 km. away in Italian Cyrenaica.

A hurried preliminary reconnaissance has so far not revealed anything in the geology of the district which throws light on the occurrence of the silica-glass, and no crater has been found in the district. Some 30 per cent. of the area is hidden by dune ranges nearly 100 m. high, but the dunes are so regular that it is probable that the surface on which they lie is featureless. The dunes run in parallel north–south ranges 2 to 5 km. apart, steep on the eastern face, with a long soft sand slope on the west, and the underlying Nubian sandstone plain, generally free of sand, has an almost imperceptible slope averaging 1 in 1000 from south to north.

The surface of this plain in the southern part of the silica-glass area is hard quartzite, overlain in places with reddish sandstone, and also in parts by a reddish alluvial deposit probably derived from weathering of the sandstone. Some of this reddish material can be seen adhering to the specimens of glass which were lying on it. Such specimens were not found more than half embedded, and though holes were dug where the glass lay thickest none was found below the surface.

Farther north the surface is a coarse quartz gravel, the pebbles of which are very rounded, while the glass shows no signs of having been rolled, though its surface is wind-eroded. As one goes north the gravel becomes finer, till at the northernmost point where glass was definitely found the surface is a thin crust of fine gravel over a white angular quartz sand. Small pieces of clear quartz are common in the gravel, and not easy to distinguish when searching from fragments of glass 3–5 mm. long. No well-worked tools of silica-glass were found, though a few flakes were certainly made by man. Only two small fragments, in company with a definite artifact of quartzite, were found actually on the sand, and these must have been carried up there and dropped.

Near the largest lumps a number of spots were found where groups of fairly large (10 cm.) fragments occur within a square metre, as though a large lump had been broken up. Attempts to fit the pieces together were unsuccessful, possibly due to the way in which the glass flies to pieces on fracture. About a hundredweight of the silica-glass was collected and brought to Cairo, though more could have been collected if transport were available.

The extent of the area over which it is distributed is only vaguely known. None was seen south of the old Kufra to Abu Mungar camel route, and the first pieces were seen about 4 km. north of this. For about 26 km. farther north up the central corridor in which it occurs pieces are visible every few yards, even from a moving car, while farther north one has to stop and search, sometimes for minutes, before a single fragment is found. 84 km. north of the old camel road it was only after considerable search that a few tiny fragments were found. The distribution in the adjacent corridors on either side was similar, though the lumps were smaller and less plentiful than in the central corridor, while pieces were also picked up in the next corridors east and west.

Dr. L. J. Spencer, F.R.S., allows us to publish the following notes on this and other material:

Silica-glass from the Libyan Desert

Seven pieces of this remarkable material have been generously presented by the Survey of Egypt for the Mineral Collection of the British Museum (Natural

History), and are now displayed in the Recent Addition Case in the Mineral Gallery at South Kensington, together with other material to which they appear to be most closely related, namely tektites from Bohemia, Moravia, French Indo-China, Australia, and Colombia. The masses are irregular in shape and are wind-worn on all sides. They range in weight from 90·4 to 2279 grams ($3^1/_4$ oz. to 5 lb.). The colour is pale greenish-yellow and the material is in part quite clear and transparent. Some parts are cloudy owing to the presence of minute bubbles, and when these are still more abundant the material has a milky white appearance. One piece shows smoke-grey streaks in the greenish-yellow glass, and indications of a flow structure are also shown in other pieces.

The clear material when cut and polished (in a step-cut form) makes quite an effective gem stone. One cut for the Museum weighs 10·57 grams (52·86 carats). The specific gravity of this was determined by hydrostatic weighing to be 2·21. On the refractometer it gave the following values for the refractive index: 1·4595 (red light, Li), 1·4624 (yellow light, Na), 1·4645 (green light, Tl). Values obtained by the prism method through a 60°-prism cut from the glass were less reliable, owing to the scattering of the rays of light by the minute bubbles. The hardness is 6 on Mohs's scale; the material readily scratches window-glass and is itself readily scratched by quartz.

This silica-glass in its characters and mode of occurrence is most closely allied to tektites. But it is found in much larger masses and in larger quantity than any tektites previously known, and also it is different in colour. Tektites are usually black and in the mass opaque, but those from Bohemia and Moravia are a clear green, and small ones from Colombia are pale smoky-grey to almost colourless. The origin of tektites is still an unsolved problem. The most generally accepted view at the present time is that they are of cosmic origin, but none has been actually observed to fall from the sky. The presence of silica-glass in large quantity around the meteorite craters recently discovered at Wabar in Arabia and Henbury in Central Australia suggested that tektites may have been formed by the fusion of desert sand in the heat developed by the fall of gigantic meteorites. No evidence of this however has been detected in the Libyan Desert.

Rocks from supposed meteorite craters

A series of rock specimens from the Kaali craters on the island of Oesel has been presented to the British Museum by Mr. J. A. Reinvaldt of Tallinn. These are white to light grey dolomite-rocks, showing a shattering of the material to angular fragments or loose powder. No evidence of any meteoritic material could be detected.

From the Bosumtwi crater in Ashanti specimens of volcanic agglomerate have been presented by the Director of the Geological Survey of the Gold Coast. These are from a small isolated patch recently discovered by the Survey on the northern outer slope of the crater rim.

From the hills around the swampy area near the Stony Tunguska river in central Siberia specimens of basalt have been received from Dr. L. A. Kulik, through Mr. R. Kirkpatrick.

So far as can be seen at present these specimens do not themselves throw light on the formation of meteorite craters.

HISTORICAL GEOGRAPHY OF THE BIENTINA DEPRESSION

Signora Elena Paderi contributes a study of physiographical changes during historic times in the Bientina depression and the plain of Lucca to volume XVII of the *Memorie* of the Royal Italian Geographical Society, in which she shows how archaeology, tradition, and topographical studies can be combined to

elucidate historical geography. The Bientina depression, to the south-east of Lucca, has been eroded in the post-pliocence alluvial deposits between Monte Pisano and the Cerbaie. In prehistoric times this area was probably covered by a lake fed by an arm of the Serchio, branching off from above the present site of Lucca. A bar of alluvial deposits prevented communication with the Arno to the south. Two Iron Age canoes have been found near Orentano at the 10-metre level, which seems to have marked the then level of the lake: later, from the sites of "Etruscan" tombs, it appears to have fallen to the 6-metre line. Local names are evidence of extensive pre-Roman settlements. It is also apparent, from the situation of Roman roads and other remains, that during the Roman Empire the rivers must have been controlled by works. With the decline of that power control broke down, the Serchio once more filled the Bientina depression, and the marshes spread. The existence of a lake near Bientina is not recorded before medieval times.

Documents refer to Lucca having been enclosed by two arms of the Serchio, and to the damage wrought in the plain by the changing of the river-bed, especially to the east when communication was re-established with the Bienta lake. The writer has been able to trace out these river courses. By the end of the fourteenth century, the lake had decreased in area, since defence works on the Serchio had diverted the feeder, and a change in the course of the Arno was draining it away to the south. The deeper parts of the lake were then probably below the 10-metre line. In the last quarter of the sixteenth century, the Serchio was confined to its western bed by dykes, and canals had been built to prevent the flooding of the plain. A dyke built by the Florentines at the south end of the lake later renewed the threat of increased flooding, but by agreement between Lucca and Florence a canal was built (1560–72) to lower the lake-level by drainage to the Arno. Unfortunately, throughout the seventeenth and early eighteenth centuries, Lucca and Florence failed to achieve an agreed solution of this problem, and conflict and disaster ensued. In 1787 the project of abolishing the lake completely, by a canal tunnelling under the Arno and reaching the sea, was broached—but was not successfully carried out until 1859. The hydrographic system of the Bientina basin is now artificial, and entirely independent of the Serchio or the Arno. Recent works have completed the drainage of the whole area, so that it is only after heavy precipitation that the lowest parts of the depression are inundated for a few days.

ASCENT OF MINYA GONKA

It was noted in the September *Journal*, at the end of the paper, "Notes on the Mountains about Tatsienlu," by Mr. J. H. Edgar, that Minya Gonka had been climbed by an American party. A more detailed account by Mr. Arthur B. Emmons, one of the climbers, is given in the *China Journal* for July. The writer and Mr. R. L. Burdsall left Tatsienlu on July 27 last year with a yak caravan, crossed the Gi La, and established a base camp near Yulong-hsi, west of the Gonka range. Here a base line was set out and a datum line established. Details of the work done are not given, though it is stated that, with the aid of a mercurial barometer, twenty-five outstanding snow peaks were measured in two weeks, before the weather broke. The height given for Minya Gonka, about 24,000 feet, is within 1000 feet of Lieut. Kreitner's figure (7600 metres or 24,900 feet), but the difference between their figures for Jara is much greater. Kreitner gave it as 7800 metres (25,600 feet), Mr. Emmons as about 18,000 feet.

They then reconnoitred the southern approaches to the mountain, crossing the Tseme La (Edgar's Tzu Mei) and descending into the Buchu valley, apparently a tributary of the Tung Ho, near Boka. They followed a route eastwards along

the valley, and then northwards into the range, where, after five days' back-packing, they set up a camp at 15,000 feet to the south-east of Minya Gonka. Three days later they attempted unsuccessfully to climb to 19,000 feet on the shoulder through fresh snow, and retired to Boka. Here they were joined by the remainder of the party, Terris Moore and J. T. Young. After climbing the shoulder, they found that cliffs and ice-cornices made the southern and eastern faces unclimbable. A long steep ridge, running north-west, which they had previously noted, seemed to offer a possible route; they therefore moved camp to the west, to the foot of a northern spur of this ridge, not far from the lamasary of Konka Gompa. With the aid of two Tibetan porters, who would not proceed farther, a camp was set up at 17,000 feet. Despite storms and height-lassitude, they reached 22,500 feet on the ridge, before deciding to return to their base. After two days' rest, they established a camp at 21,500 feet, from which, on October 28, Messrs. Moore and Burdsall reached the summit, Young having remained in charge of supplies, and Emmons having damaged his hand. The latter was badly frostbitten, and forced to spend a night in the open, just below the snow-line. This is claimed to be the highest peak climbed by Americans. The paper is illustrated by several photographs of the mountain.

EXPEDITION TO THE EASTERN KARAKORAM

Dr. H. de Terra, who accompanied the late Dr. Trinkler on his last expedition to Central Asia, led in 1932 an expedition to northern India on behalf of Yale University and the American Geographical Society. Its objects were mainly geological and biological. A short general account is given in *Science* (vol. 77, pp. 497–500), and a longer narrative of the exploration of the Eastern Karakoram in the *Himalayan Journal* (vol. 5, pp. 33–45). The party, accompanied by Khan Sahib Afraz Gul Khan, of the Survey of India, left Leh towards the end of June, and reached the Pangong Tso *via* the Shakya La and Tankse. Biological research was carried out in the lake: the deepest sounding obtained was 49 metres, near Mang on the western shore. The conspicuous clay beds were found to be inter-glacial. As later observations on the eastern shore proved, a rise of 10 to 12 feet in the lake-level has taken place in the last half-century. The party then turned northwards into the upper valley of the Ku-Lungpa, where they were able to examine the Pangong–Shyok watershed. This, an extension of the Muztagh Karakoram, rises abruptly to over 21,000 feet from the plain, which was judged to be a remnant of the former great extension of the Tibetan plateau. The Ororotse Tso, a lake of great biological interest, was visited.

Returning to Chagra, they reached Kyam in the upper Chang-chenmo valley. This valley is an important geological boundary, for here the marine sediments of an ancient mesozoic sea abut upon older metamorphic rocks. The presence of the former confirms the previous existence of the Tethys sea. On the journey back to the Pangong Tso by Niagzu, Dr. de Terra concluded from his observations that it is possible to trace the Muztagh-Karakoram "from the Shyok bend over the Marsimik La and south of Drogpo-Karpo to the Tibetan frontier, south of the Lanak La, where it loses its most characteristic features." From Shushal the party returned across the Indus to the Tso Morari, where remnants of the former Tibetan plateau were again encountered, Gya and Leh. On this expedition 4600 square miles between Leh and the Tibetan border were mapped on the scale of 2 miles to 1 inch; the geological structure of the area disentangled, and important collections of fossils, lake fauna, and plants made.

THE MALTESE TRAVELLER DE BONO

Those who have read the books of Speke and Baker will remember various references there made to the Maltese trader Andrea De Bono, with whose agents

both travellers came in contact, with no great satisfaction to themselves. Neither seems to have actually met the principal himself, though his people claimed for him rather than Petherick the merit of such help as was afforded Speke on his northward journey down the Nile. On one occasion they declared De Bono to be "the same as Petrik"—a puzzle which has never been satisfactorily solved. The general impression gained from the narratives is that De Bono was no very estimable person, though it may be that he suffered for the sins of his servants, to which the strong term "atrocities" is once applied by Baker. It has been the pious object of a Maltese writer, Mr. S. B. Galea, to present De Bono in a more favourable light, and he has kindly sent us a pamphlet (Valetta, 1933) embodying the result of careful efforts to glean such scattered notices of his compatriot's life and activities as he could find. While not disguising the fact that De Bono was a trader rather than an explorer he points to some of his journeys as deserving praise for the pioneer work done. The first, undertaken in 1855 with two companions—Terranuova and Cremona—led some distance up the Sobat, then explored for the first time. Subsequent journeys up the White Nile, the first two with Miani and Peney respectively, took him at last as far as lat. 3° 10′ N., beyond which no trader had then advanced from the north. But as various other traders were then active on the Upper Nile (including the Frenchmen Brun Rollet, Lejean, Poncet, etc.), besides the Austrian missionaries Vinco, Knoblecher, and others, it is difficult to assign the special character of a pioneer to any one person.

The writer has collected his material with much industry from various sources (De Bono himself published one short narrative only), drawing, for instance, upon the 'Annales de Voyages,' 'Tour du Monde,' and Almagià's recent work on the contributions of Italians to our knowledge of Egypt (Rome, 1926); and it is useful to have the information thus brought together. It may be true that De Bono was not entirely responsible for the evil doings of his agents, but we cannot ignore the connection necessarily existing at the time between the trade in ivory and that in slaves, as was forcibly urged in a Foreign Office letter to Consul Petherick in 1865.

De Bono seems to have remained on the Upper Nile till 1868, after which his health broke down. He visited Rome, Paris, and London, but died in Cairo in 1871.

GEOGRAPHIC SURVEYS IN NORTH AMERICA

Reference was made in the *Journal* for June (p. 543) to the development of land use surveys in the United States, and particularly to a survey of Alger County, Mich. Another example of the work being done is given in Bulletin No. 9 of the Geographic Society of Chicago (distributed in England by the Cambridge University Press), entitled "Geographic Surveys" by Messrs. V. C. Finch and R. S. Platt. Geographic Surveys, as Mr. Finch explains, here mean an intensive study of a small, representative area, rather than the whole region, in regard to (i) visible elements of the landscape, and (ii) social and economic relationships. In the first case, the factors recognized are degree land of slope, soil, drainage, and land use. The intensity of the study is apparent from the statement that all changes of "complex" involving a minimum of one acre have been recorded in the example described later, and that these "complexes" may number from 40 to 150 per square mile. What is described as a "fractional code" has been evolved for recording observations upon the map. The numerator refers to major use of land, the crop and its condition, the denominator to slope, soil type and drainage: thus 121/11 signifies tilled land, with good oats crop, on level Marshall silt loam.

Mr. Finch then examines the district around Montfort, south-west Wisconsin, on these lines, and presents a map on the scale of 2·75 inches to the mile. From this base map it is possible to prepare others, showing for example distribution of major tilled crops, and relation of tilled land to slope. His essay summarizing the main results gives an interesting picture of a livestock farming region of the Middle West. Montfort lies on the crest of the Galena–Trenton "cuesta," so that he is able to bring out the contrasts between the level prairie upland of large farms, with three-quarters of their area in tillage—mainly corn—and the smaller farms of the northern escarpment, much eroded, with half their land under permanent pasture, and hay the principal crop. This area is largely occupied by Bohemians, who arrived after the tableland had been settled by immigrants from the Eastern States and Germany.

A contrasting region, the pueblo of Magdalena Atlipac, in the Valley of Mexico, is then described by Mr. R. S. Platt. Within this area of about 4 square miles, five types of land with characteristic utilization are distinguished, ranging from mountain slope to the wet plain formerly occupied by Lake Texcoco. The centre of the community is the belt of corn-fields—an average family holding of which is 3 acres, with 8 acres on the mountain, and 2 on the wet plain. There is little specialization of labour, or commercial activity.

HYDROGRAPHY OF DENMARK STRAIT

In connection with the Norwegian marine biological investigations it was arranged in the spring of 1920 for two observers, Messrs. Braarud and Ruud, to sail for Denmark Strait in the sealer *Øst*, one of the vessels sent annually from Aalesund to catch hooded seal; and their results are in course of publication in the series entitled *Hvalrådets Skrifter*, the first instalment dealing with the hydrographical results (no. 4, part 1, 1932). The *Øst* is one of the largest sealers sent to that region, and was able to push through the ice in a way impossible for the smaller vessels used by scientific expeditions, while on the other hand the scientific work was necessarily subordinated to the commercial objects of the voyage, so that the plan of observation could not be very systematical. But every opportunity offered during the zigzag course of the vessel was utilized for the collection of samples, and complete series from 1 m. to just above the bottom were secured from twenty stations. The result of the soundings was generally to confirm the views of Nansen as to the configuration of the sea-bottom. The submarine shelf on the Greenland side, which falls steeply to the deep water nearer Iceland, was found to be broadest on the line of the ridge connecting the two lands, becoming narrower to the south, though with a projecting tongue in about lat. 66° N. The existence of a submarine fjord outside Kangerdlugsuak was confirmed. The paper describes in detail the various sections taken and the mutual relations of the strata of Polar, Local Arctic, and Atlantic water (with their several admixtures) marked by differences of temperature and salinity. The Polar water (with temperature not above 0° C.) forms the surface layers over the entire continental shelf, not reaching as a rule below 100 m. It is supplied mainly by the Polar current. Atlantic water is found only in the two branches of the Irminger current, one of which washes the banks off Iceland, while the other is deflected west to join the Polar current. On the Greenland bank the regular flow of the Polar current is broken by tidal movements, and it was found that the currents were sometimes in opposite directions in the upper and lower layers. The position of the ice-border at various dates was carefully studied. It may change quite remarkably in a short time, but the changes seem to be of the nature of a pulsation about an average, which was found pretty constant in spite of prevailing northerly winds. The

melting of the ice on drifting into warmer Atlantic water had no essential influence on the position of the border, the current conditions being a more important factor, and these in turn are ultimately due to the configuration of the sea-floor. During the cruise much material was collected concerning the nourishment of the sharks, which consisted mainly of cod, of which great numbers were seen in the upper layers of Atlantic water.

ADMINISTRATION OF BOUVET AND PETER I ISLANDS

We are informed by the Foreign Office that a despatch received from His Majesty's Minister in Oslo transmits a Norwegian law of 24 March 1933 taking Peter 1st Island under Norwegian sovereignty and that a Royal Resolution of July 13 provides for the administration of that island. By the law of 27 February 1930 Bouvet Island was taken under Norwegian sovereignty. Norwegian civil law, criminal law, and laws of judicial procedure are applied to the island, the King being empowered to make such modifications with regard to laws concerning judicial procedure as may be necessitated by local conditions, and to decide what other laws shall be applicable. All land which has not been transferred to private owners belongs to the State, and no person can acquire ownership of State land. This law has now been extended to include Peter 1st Island, and the Royal Resolution of July 13 announces that the administration of the latter island is being taken over by the Ministry of Commerce. The duties of Superintendent of Police are vested in the Ministry of Justice. The Circuit Court of Oslo is the Circuit Court of Peter 1st Island which is a separate judicial district under the Oslo Town Court. Certain regulations in the law relating to Svalbard of 17 July 1925 are also applied to Peter 1st Island.

PLATO'S ATLANTIS

A further contribution to the vexed problem of Plato's 'Atlantis,' by W. A. Heidel, is contained in the *Proceedings* of the American Academy of Arts and Sciences (vol. 68, pp. 189–228). The writer urges that the story of the lost continent must be considered only with reference to Plato's thought, for, excepting Plato, there is no evidence for its existence. The story Critias is made to relate is said to have been told to Solon in Egypt by the priests of Sais, who could not be relied upon for events which had taken place nine thousand years before Solon's time, and a thousand years before the founding of Sais. There is evidence that Critias's story was intended to be recognized as fiction. A story with similar details is recorded by Herodotus, which Plato must have had in mind. In selecting a position for Atlantis he was merely following Greek tradition from Homer down. Mr. Heidel, believing that many of the details of Atlantis were drawn from the Ionian geographers, proceeds to "examine the tradition of ancient geography for the necessary points of support for the fiction of Atlantis." One feature was the successive catastrophes—these were ready to hand in Greek mythology; another the supposed shoals beyond the Strait of Gibraltar. He is able to cite attempted circumnavigations of Africa obstructed by shoals, and particularly the legend of Heracles. Finally, though here the argument is not clear, he discusses contemporary knowledge of Africa, and suggests that these shallows were "the reminders of a cataclysm which had engulfed the ancient land-bridge between Asia and Africa." The writer does not claim to have solved the problem, but suggests that "it is more reasonable to look for the answer in Greek history and geography than in the latest findings of modern geology."

CORRESPONDENCE

THE PENEPLAINS OF EAST AFRICA

Mr. Wayland, Geologist of Uganda, having courteously cited my observations on the extent of the peneplains of East Africa (*Geogr. J.*, July 1933, p. 95), I take pleasure in confirming his brief statement and would like to advance the general understanding of the problem by a somewhat fuller account. The area over which I have traced the physiographic features of the varied landscapes comprises Tanganyika Territory, Rhodesia, the Eastern Congo, Uganda, western Kenya, and the southern Sudan. That I was able to do so was due to the very generous co-operation of the geological departments and officials of the several countries, without whose aid the journey could in large part not have been accomplished.

Bornhardt and von Staff first recognized the peneplains of the eastern coastal region of Tanganyika and identified two, namely, one which is still in part covered by Jurassic sediments and must have developed during the earlier Mesozoic, and the second which is planed across Cretaceous strata and must be of late Cretaceous and/or early Tertiary age. Wayland and Combe have identified in Uganda, 1000 miles from where the Germans observed, also two peneplains, the older capping the highest and most resistant ridges of Ankole and Ruanda, the younger extending over areas of granite, schist, and gneiss. The interval between the two sufficed for the almost complete erosion of the older surface to a depth of 2000 or 3000 feet and represents a long time, even in geologic chronology. The completion of the younger peneplain is dated by the occurrence of dinothere remains as of Miocene age, and its development must have covered the earlier Tertiary. It may have begun during the late Cretaceous.

The younger of these two peneplains, designated by Wayland as Peneplain II and by me as the Tanganyika plain, can be traced continuously from Uganda to south-eastern Tanganyika, where it is represented in the Iringa highlands and Livingstone mountains high on the borders of Lake Nyassa. It varies in elevation from 4000 to 10,000 feet above sea, having been strongly warped during the later elevation of the continent. It is also faulted, being displaced vertically by the rift faults. We may thus step it down from the Iringa highlands to the coastal region, where it is obviously to be correlated with the post-Cretaceous peneplain of von Staff.

The older of these two peneplains is, of course, the higher in regions where it has been in part eroded and the lower where it has been buried under sediments. We may thus correlate von Staff's pre-Jurassic plain with Wayland's Peneplain I.

Engraved in Peneplain II is a younger phase of topography, represented by wide valleys, which are sunk to a depth of 200 or 300 feet, as a rule, below its level. The stage of development reached in the topographic cycle is past maturity, but not yet peneplanation, though Wayland, I understand, refers to it as Peneplain III. I would describe the landscape as a matureland. It corresponds in age with the warping which initiated the formation of the rift valleys, and may have begun in the Miocene. I am inclined to think it not older than Pliocene. It is typically developed in the warped region north of Lake Victoria in the vicinity of Jinja and Entebbe, and also in certain areas, though not everywhere, near Lake Tanganyika, as, for instance, in the Malagarasi valley and on the plateau south-east of Abercorn. It can also be recognized in some of the steeper coasts of the lake, where however the fact that it is tilted to an angle of 15 or 20 degrees makes recognition more difficult.

Incised in the valleys of the matureland or in Peneplain II where that stage

is lacking are the sharp ravines that are being carved in consequence of the pronounced changes of attitude and level accompanying the formation of the rift valleys, chiefly during the Pleistocene.

I note that Wayland refers guardedly to the uncertainty of long-distance correlations of the peneplains, and I have no doubt that future workers, himself included, will modify the broad identifications here stated by recognizing local details as pertaining to minor and different periods. But it is a fact of very great significance in any general study of African geology that Peneplain II or the Tanganyika plain, as I would prefer to call it, can be traced continuously from the Sudan to Rhodesia, and from the Congo to the coast on the east. It constitutes a datum plain by which to determine the degree of warping of the continental surface in post-Miocene times and with reference to which both older and younger features may be compared.

Mr. Vincent's charming account of the Namuli mountains of Portuguese East Africa (*Geogr. J.*, April 1933) describes a region not far distant from and closely resembling the classic landscape in which Bornhardt first observed the great granitic "inselberge," and it should not be difficult to establish the identity of similar stages of planation in the two contiguous districts. In the type area the inselberge rise abruptly from the oldest peneplain, that of pre-Jurassic age. Elsewhere, where that plain has been eroded and replaced by the Tertiary peneplain, they still survive and dominate the landscape, their bases having been lowered to the lower surface of planation, while their summits have lost comparatively little. They appear to be residuals of chemically and physically resistant rock, which have withstood the etching that removes the surrounding rock masses. They have been left in stark relief by the long-continued, though interrupted processes of weathering, decay, and wear that are peculiarly active in tropical zones. There are of course other types of residual heights, which should not be confused with true inselberge, but Vincent's photographs are exceedingly characteristic and leave no doubt of the kind of monadnock represented by the splendid peak of Namuli. It is a peer of those striking examples that stir the admiration of the traveller as he enters the harbour of Rio de Janeiro, with Sugarloaf on the left and Corcovado ahead.

As Dr. Parkinson observed in discussing Vincent's paper, there is a parallelism between the three peneplains of East Africa and the three described by Professor Frank Adams as occurring on the island of Ceylon beyond the Indian Ocean. Correlation of the two series could be established only by independent evidence in each area of the geologic age of each peneplain, and even then might be regarded as a coincidence, since peneplains are enormously long lived and it would be probable that they should be more or less contemporaneous where three of them have developed during post-Jurassic time. It may be worth while, nevertheless, to follow Parkinson's thought a little farther.

Ceylon and Africa lie on opposite sides of the Indian Ocean basin, in a relation similar to that between England and the eastern provinces of Canada and the United States. It is well known that the latter have closely parallel histories in so far as mountain-building epochs are concerned, and the facts of world history justify in general the statement that opposite coasts of ocean basins have experienced contemporaneous disturbances, whereas opposite shores of continents have exhibited diverse effects during any given geologic age. If it should eventually be shown that the uplifts of Africa and Ceylon have occurred somewhat simultaneously, in terms of geologic epochs, the general principle would receive another illustration.

BAILEY WILLIS

Stanford University, California. 29 *July* 1933.

the pro-
f the rift

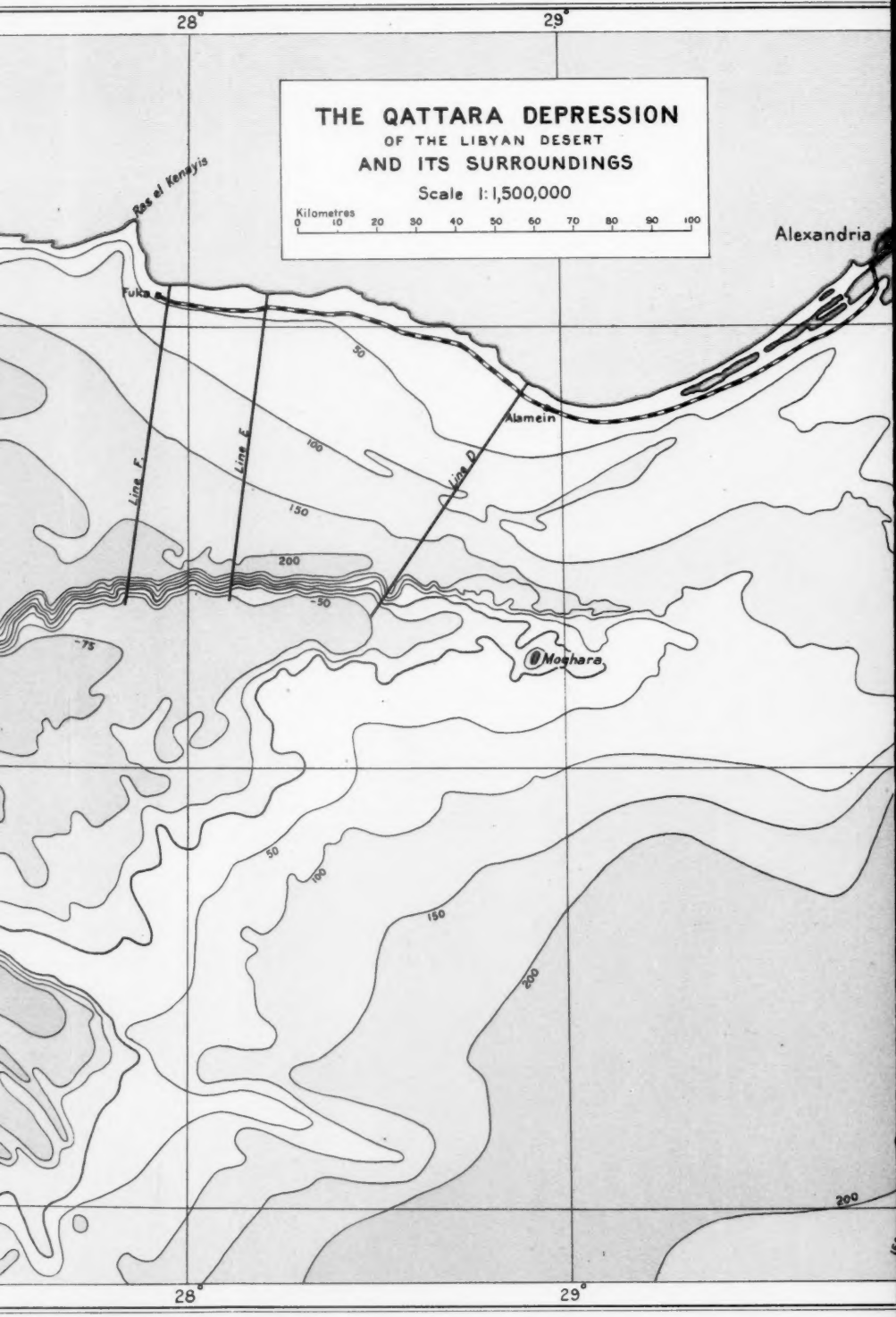
-distance
, himself
ing local
ery great
II or the
from the
stitutes a
ntinental
lder and

uese East
nd closely
the great
dentity of
e area the
assic age.
iary pene-
ving been
lost com-
physically
rrounding
ed, though
arly active
nts, which
graphs are
ock repre-
examples
de Janeiro,

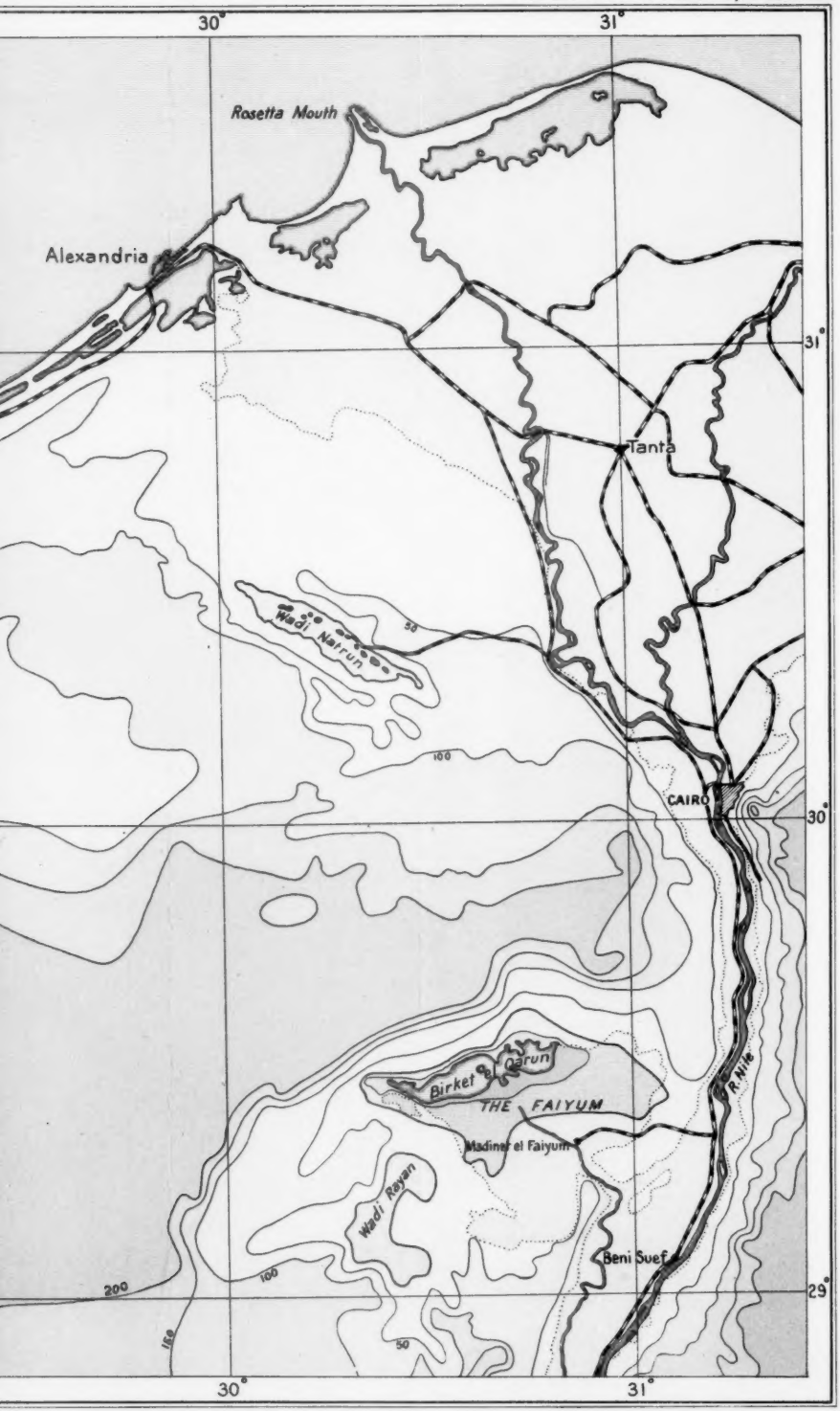
parallelism
y Professor
ian Ocean.
nt evidence
might be
ived and it
eous where
orth while,

n a relation
da and the
histories in
orld history
have expe-
continents
f it should
d somewhat
ould receive
LEY WILLIS

Printed by the Survey of Egypt for the Royal Geographical Society. P. 33/646. 1933


28°
29°
THE QATTARA DEPRESSION
OF THE LIBYAN DESERT
AND ITS SURROUNDINGS
Scale 1: 1,500,000
Kilometres
0 10 20 30 40 50 60 70 80 90 100
Ras el Kenayis
Alexandria
Fuka
Alamein
Line F
Line E
Line D
50
100
150
200
-50
-75
Moghara
50
100
150
200
200
28°
29°

Alexa



QATTARA DEPRESSION
Ball